New Scientist

WEEKLY 11 January 2025

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THE END OF THE MULTIVERSE?

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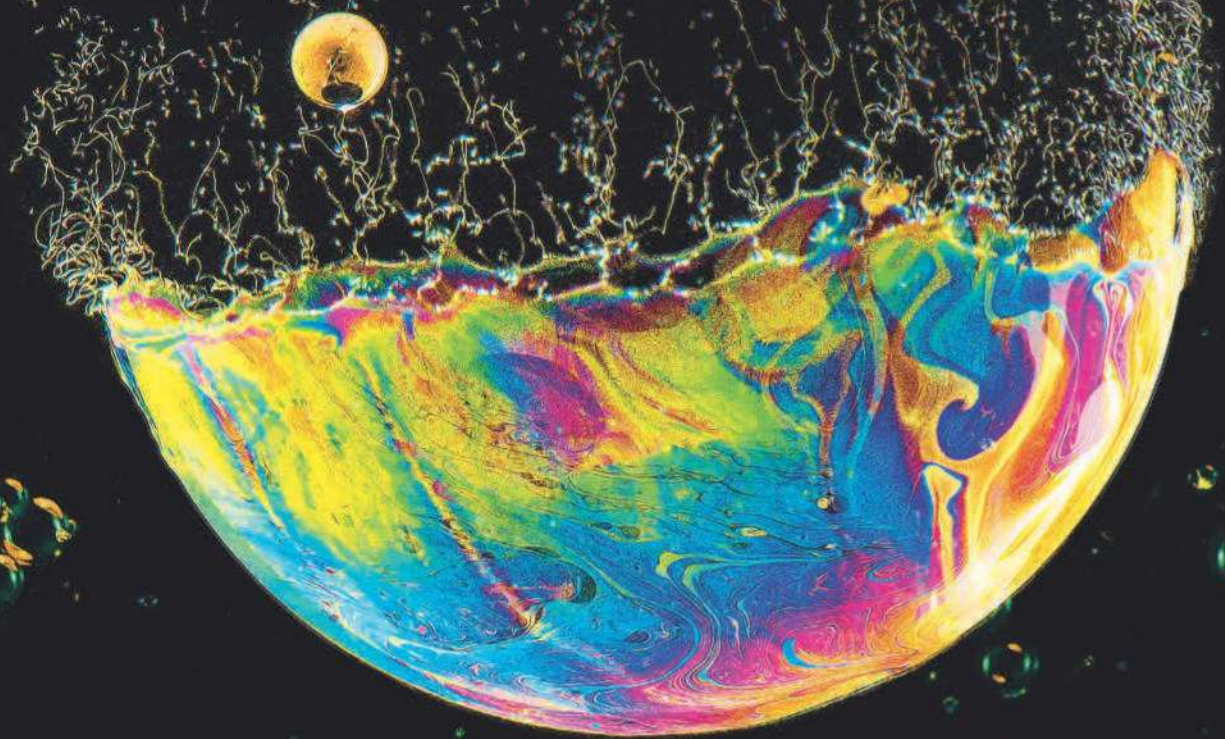

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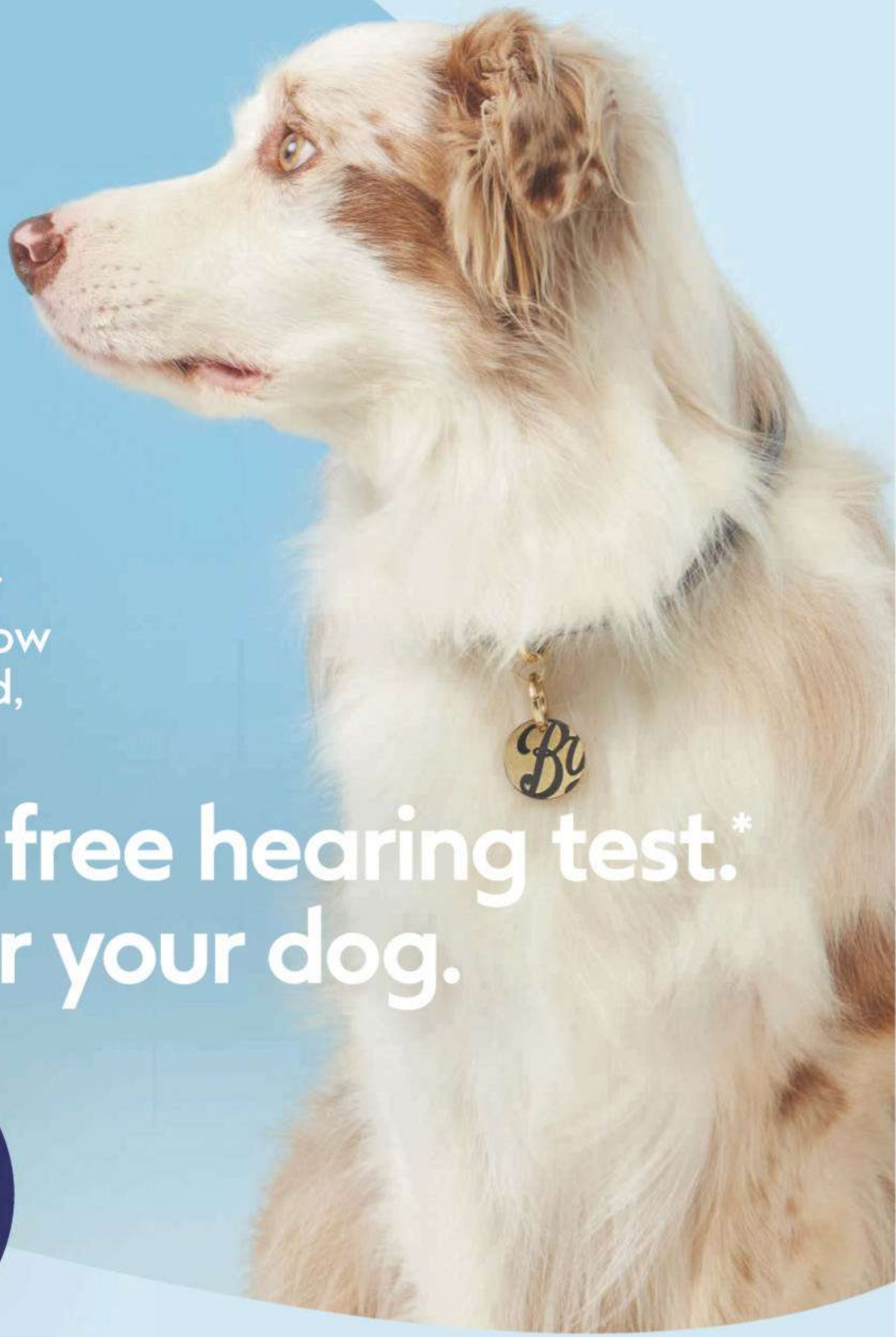

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Incredible cosmology

Powerful telescopes and computers are rapidly advancing what we know about the universe. From the nature of dark matter and dark energy to the origins of the universe itself, scientists are tackling big questions that challenge our understanding of reality. On 15 March at London's Congress Centre, join six world-leading experts as they reveal the latest research on our cosmos.

newscientist.com/events

Tour

Tasmania's flora, fauna and geology

Join biologist Martin Cohen on an immersive expedition around the coasts, wetlands, rainforests, national parks and alpine landscapes of Tasmania. You can expect to see Tasmanian devils, platypuses, little penguins and the eastern quoll. Plus, discover the island's Aboriginal culture. This 12-day tour starts on 1 April and costs £5795.

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Podcast

Weekly

Rowan Hooper hosts a panel of *New Scientist* journalists as they highlight their favourite moments from 2024. Hear about supersonic volcanoes that spew diamonds and the story of Thorin the Neanderthal, whose remains are shedding light on how the ancient species died out. Plus, find out how researchers were able to reanimate a pig's brain this year.

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Natural bounty Go birdwatching in Tasmania's diverse ecosystems

ERIK BESER, ICECUBE/NSF

Neutrino hunting New detections could reveal cosmic mysteries

Video

Super zooplankton

Zooplankton store carbon from the atmosphere then help transport it to the deep ocean. Without this carbon pump, atmospheric carbon dioxide levels would be 50 per cent higher than they are today. But as our oceans warm, zooplankton are threatened. BIO-Carbon is a programme funded by the UK government that aims to uncover the climate effects of zooplankton.

youtube.com/newscientist

Newsletter

The Earth Edition

Try the first instalment of this newsletter, where each month environment reporter Madeleine Cuff will take you through *New Scientist*'s must-read climate and nature news. In this look back at 2024, find out about our top 10 stories of the year, involving pink pigeons and concerning trends in the jet stream.

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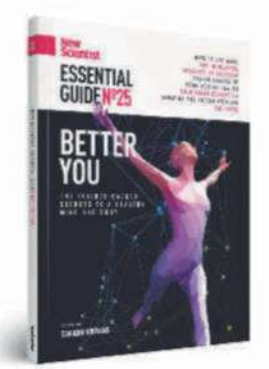
Podcast

"There's no agreement as to what death is and when you cannot bring someone back from it"



Essential guide

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1 Over the ten years to 31 July 2024, the US dollar NAV per share compound annual growth rate ("CAGR") was 13% and the public market comparator (the FTSE All-World Total Return Index) CAGR was 9%.

2 Please also note the "NAV per share" percentages in the table above reflect the US dollar monthly estimated NAV per share.

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A healthy dose of AI

Deployed in the right way, artificial intelligence in medicine can save lives

DOCTORS, as a whole, are a pretty clever bunch, but they can be resistant to change. The most famous example is probably the 19th-century surgeons who refused to wash their hands when moving from mortuary to labour ward, spreading as-yet-undiscovered microbes and leading to infant deaths. Hungarian physician Ignaz Semmelweis, who collected statistics to make the case that soap and water could save lives, was ridiculed and ostracised.

Today, we live in more enlightened times, and medical practice is generally backed by evidence – but are we always getting the right evidence to bring about change? For example, there are signs that bringing artificial intelligence into clinical use could also save lives. As we report in our main story on page 8, radiologists who chose to use an image-classifying AI to help spot breast cancer picked up an extra case per 1000 people screened. Across healthcare systems, the effect could be big.

Does that mean we should encourage doctors to hang up their scrubs and let the machines take over? Far from it. While

"We should be bolder in testing medical AI systems in real-world settings"

large language model AI systems like ChatGPT can ace multiple-choice medical tests, they do less well on conversational diagnoses (see shorter story on page 8). A medic with a good bedside manner and listening ear is still vital, for now.

Instead, there are two conclusions we can draw from these studies. The first is that we should be careful about using the generic term "artificial intelligence". Although the two systems we report on share an underlying neural network technology, image classification is a very different task to text generation, and the latter has a much higher risk of the AI spitting out plausible but incorrect results. In other words, not all AIs are made equal.

The second conclusion is that we should be bolder in testing medical AI systems in real-world settings, rather than just in the lab or simulations. The breast cancer study, by giving radiologists control over when to use AI, shows it can be a useful tool. With a push to get more evidence like this, lives could be saved, just as after Semmelweis, who is now considered a medical hero. ▮

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Astronomy

Celestial peek-a-boo

THIS beautiful image shows Saturn re-emerging from behind our moon after a lunar occultation on 4 January. These occur when the moon passes between Earth and another object in the night sky, blocking it from our view. To the right of Saturn, you might just be able to make out the star 85 Aquarius, which underwent occultation at the same time.

THIERRY LEGAULT

Technology

AI boost to cancer detection

Radiologists who chose to use AI assistance were better at identifying breast cancer in a large, real-world test, finds **Chris Stokel-Walker**

ARTIFICIAL intelligence models really can help spot cancer, according to the largest study of its kind, which found using AI helped radiologists identify an extra 1 in 1000 cases of breast cancer.

Alexander Katalinic at the University of Lübeck, Germany, and his colleagues worked with almost 200 certified radiologists to test an AI trained to identify

"The technology is ready; we now need policymakers to accelerate AI adoption in breast screening"

signs of breast cancer from mammograms. The radiologists examined 461,818 women across 12 breast cancer screening sites in Germany between July 2021 and February 2023, and for each person could choose whether or not to use AI. This resulted in 260,739 being checked by AI plus a radiologist, with the remaining 201,079 women checked by a radiologist alone.

Those who elected to use AI successfully detected breast cancer at a rate of 6.7 instances in every 1000 scans – 17.6 per cent higher than the 5.7 per 1000 scans among those who chose not to use AI.

Similarly, when women underwent biopsies following a suspected detection of cancer, those who were diagnosed with AI were 64.5 per cent likely to have a biopsy where cancerous cells were found, compared with 59.2 per cent of the women where AI wasn't used (*Nature Medicine*, DOI: 10.1038/s41591-024-03408-6).

The scale at which AI improved detection of breast cancer was "extremely positive and exceeded our expectations", said Katalinic in a statement.

"The goal was to show non-inferiority," says Stefan Bunk at Vara, an AI company also involved in the study. "If we can show AI is not inferior to radiologists, that's an interesting scenario to save some workload. We were surprised we were able to show superiority."

Over-reliance on AI in medicine has worried some because of the risk it could miss some signs of a condition or could lead to a two-track system of treatment where those who can pay are afforded the luxury of human interaction. There was some evidence that radiologists spent less time examining scans that AI had already suggested were "normal" – meaning cancer wasn't likely to be present – reviewing them for an average of 16 seconds, compared with 30 seconds on those that the AI couldn't classify.

"The study offers further evidence for the benefits of AI in breast screening and should be yet another wake-up call for policy-makers to accelerate AI adoption," says Ben Glocker at Imperial College London. "Its results confirm what we have been seeing again and again: with the right integration strategy, the use of AI is both safe and effective."

He welcomes the way the study allowed radiologists to make their own decisions about when to use AI, and would like to see more tests of AI performed in a similar way. "We cannot easily assess this in the lab or via simulations and instead need to learn from real-world experience," says Glocker. "The technology is ready; we now need the policies to follow." ▮

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Image-classifying AI can be used to study mammograms

Can AI listen to patients?

Advanced AI models score well on professional medical exams but still flunk one of the most crucial physician tasks: talking to patients to gather medical information and deliver an accurate diagnosis.

"While large language models show impressive results on multiple-choice tests, their accuracy drops significantly in dynamic conversations," says Pranav Rajpurkar at Harvard University.

Rajpurkar and his colleagues created an AI benchmark tool called CRAFT-MD that evaluates a clinical AI model's reasoning capabilities based on simulated doctor-patient conversations, developed from 2000 medical cases drawn from US medical board exams.

Multiple experiments showed that four leading large language models – OpenAI's GPT-3.5 and GPT-4, Meta's Llama-2-7b and Mistral AI's Mistral-v2-7b – performed considerably worse on the conversation-based benchmark than they did when making diagnoses based on written summaries of the cases. OpenAI, Meta and Mistral AI didn't respond to requests for comment.

For example, GPT-4's diagnostic accuracy was an impressive 82 per cent when it was presented with structured case summaries and allowed to select the diagnosis from a multiple-choice list of answers. When it had to make diagnoses from simulated patient conversations, however, its accuracy dropped to just 26 per cent (*Nature Medicine*, doi.org/g8xhs8).

The AI models also failed to gather complete medical histories a significant proportion of the time, with leading model GPT-4 only doing so in 71 per cent of simulated patient conversations. Even when the AI models did gather a patient's relevant medical history, they didn't always produce the correct diagnoses.

Jeremy Hsu

Zoology

Scorpion 'spits' venom to defend itself from predators

Michael Le Page

A COLOMBIAN scorpion that is new to science can spray venom from its stinger to hit something up to 35 centimetres away rather than always having to inject it. The tactic is thought to be a way of defending against would-be predators.

It isn't known what effect the venom has when it hits an animal, says Léo Laborieux, who made the discovery while at Harvard University. "But a fair guess is that this is going to cause some irritation and pain," he says. "It's probably not too serious, but definitely something you don't want to mess with."

The discovery was serendipitous. Laborieux had set out to trap and study moths in central Colombia with a visiting researcher. When that failed, they caught scorpions instead and gently prodded one with a stick to study its defensive behaviour. "Then I noticed this weird line of small droplets on the side of the cup," says Laborieux. "The thought occurred to me that it could be venom spraying, but I didn't really believe it."

Back in the lab, videos confirmed that the scorpions do indeed spray venom from the stinger on their tails when threatened (*Zoological Journal of the Linnean Society*, doi.org/nznj). The animals also turned out to be a new species, now named *Tityus achilles*. ▮

LÉO LABORIEUX

Tityus achilles sprays venom from its stinger when threatened

Climate change

Permafrost thaw beneath Arctic lakes poses threat

Madeleine Cuff

THE ASAHI SHIMBUN VIA GETTY IMAGES

Thermokarst lakes, formed from thawing permafrost, in Alaska

AS THE Arctic gets warmer, large quantities of greenhouse gas could be released from the sediment at the bottom of lakes, a source that has previously been overlooked.

The frozen soil of the Arctic has already started to thaw, triggering the release of more methane and carbon dioxide into the atmosphere. This climate feedback is well known, but most modelling only accounts for thawing in the top 3 metres of Arctic soil.

Deep sediment may also pose a grave threat, scientists have now discovered, with tests suggesting Arctic lakes could be triggering a thaw of permafrost at much deeper levels than expected.

Thermokarst lakes are formed when permafrost thaws, creating hollows where meltwater collects. They are a common feature in Arctic landscapes, with some being hundreds of years old, and they are increasing in number as the world warms.

Water in thermokarst lakes transfers heat into the sediment below, accelerating the thaw of deep permafrost under the lake bed. Once thawed, microbial activity emerges in this ancient sediment, triggering the release of carbon dioxide and methane.

Nancy Freitas at the University of California, Berkeley, and her colleagues set out to better understand whether thawing permafrost beneath lakes could be producing significant levels of greenhouse gases.

They used a 20-metre sediment core taken from Goldstream Lake in Alaska to assess how microbial activity differed across sediment layers and under varying temperature conditions.

30–90
million tonnes of emissions per year may come from Arctic lakes

Sediment at the base of the core, 20 metres below the lake bed, was 1.45°C (34.6°F) when extracted, and therefore not frozen. Microbial activity was already evident at this temperature, says Freitas.

When core samples were exposed to temperatures of 4°C, 10°C and 20°C (39°F, 50°F and 68°F), emissions increased, suggesting more greenhouse gases will be released as the sediment warms under climate change (*Nature Geoscience*, doi.org/nzv2).

Deeper sediments are the most carbon-rich, and so could constitute a large source of emissions if they are disturbed under future warming. The team also observed significant production of methane – a greenhouse gas many times more powerful than carbon dioxide – under oxygen-free laboratory conditions. This implies that methane emissions can occur deep beneath the surface, says Freitas.

"Findings like these indicate to us that we do not yet fully understand what some of the climate effects and their feedbacks are within these ecosystems," she says.

The study assessed greenhouse gas production in samples taken from just a single sediment core. Assuming the same processes are occurring under similar lakes across the Arctic, this could amount to an additional 30 to 90 million tonnes of emissions per year not currently accounted for in models. This is a conservative estimate, says Freitas, but nevertheless it is "significant in scientific terms". "Emissions that are released in the Arctic don't just stay in the Arctic," she adds.

Ylva Sjöberg at Umeå University in Sweden says the study sheds new light on thawing happening in deep Arctic sediment. "It's another part of the permafrost carbon feedback," she says. "We should put more effort into quantifying it." ▮

Analysis Health

Why US obesity rates have fallen for the first time in decades

After years of rising, the obesity rate dipped slightly in the US during 2023, though experts disagree about the exact cause, finds **Grace Wade**

FOR decades, rates of obesity in the US have climbed – but that trend may be changing. The number of adults with the condition dipped ever so slightly in 2023, suggesting the country has reached a turning point in this public health crisis. The rise of weight-loss drugs, such as Ozempic and Wegovy, has prompted some to suggest these may be driving the shift. But it isn't that simple.

Obesity rates began to rise in the US during the 1970s. Between 1976 and 1980, 15 per cent of adults in the country were considered obese. By 2000, that number had exceeded 30 per cent. Now, more than 40 per cent of US adults have obesity, which markedly increases the risk of heart disease, type 2 diabetes, stroke and certain cancers. Many other countries have seen a similar trend, from the UK and Australia to Mexico and India.

Poor nutrition and sedentary lifestyles are often blamed for the epidemic. Yet obesity rates have refused to budge in the face of countless public health campaigns aimed at improving diet, limiting calorie intake and increasing physical activity. "Obviously there have been many efforts to curb this epidemic – calorie labelling and new nutrition guidelines, as an example – and we've yet to see any real measurable impact," says John Brownstein at Harvard University.

That is why it came as a shock when he and his colleagues found rates had declined in 2023. Over a decade, they collected nearly 48 million measurements of body mass index (BMI) from more than 16.7 million adults in the US. They found that the proportion of those with obesity – defined as a BMI of 30 or greater – rose each year between 2013 and 2021, from about 40 per cent to almost 45 per cent. It then plateaued in 2022 before dipping in 2023, though only by a small amount: less than 1 per cent (*JAMA Health Forum*, doi.org/g8vkcp).

Still, the finding is noteworthy. "We've been seeing an increase [in BMI] every year for as long as we can remember," says Brownstein. "So even the fact that we're seeing anything at a population level is important and striking."

Yet what is driving this isn't entirely clear. Brownstein and his colleagues believe it may be due to medications like Ozempic and Wegovy, which contain a drug called semaglutide that can help people lose up to 15 per cent of their body weight in a year. Semaglutide was initially approved in the US for treating type 2 diabetes in 2017 and then for treating obesity in 2021. Nearly 5 million people there – which is about 1.7 per cent of the population – were prescribed it in 2023.

The covid effect

The researchers examined health insurance claims for about 10.6 million of the people in their study. This showed that 6 per cent of those participants in the southern US had received semaglutide compared with 5.1 per cent in the north-east, 4.4 per cent in the Midwest and 3.4 per cent in the western part of the country. The south was the only region to see obesity rates decline, so Brownstein says this suggests that semaglutide was the main driver.

However, the covid-19 pandemic probably played a substantial role. "I really think that this [trend] is most likely, unfortunately, just showing the tragic loss of lives from covid-19 that really struck people who had obesity and other conditions," says Dariush Mozaffarian at Tufts University in Massachusetts.

Obesity significantly raises the risk of dying from covid-19. Other health conditions associated with obesity, such as heart disease, type 2 diabetes and high blood pressure, raise the risk even further. Not only does the southern US have some of the highest rates of obesity in the country, but it also had the highest death rate from covid-19. The modest difference in semaglutide prescriptions between the south and other regions isn't enough to explain the stark contrast in obesity rate changes, says Mozaffarian.

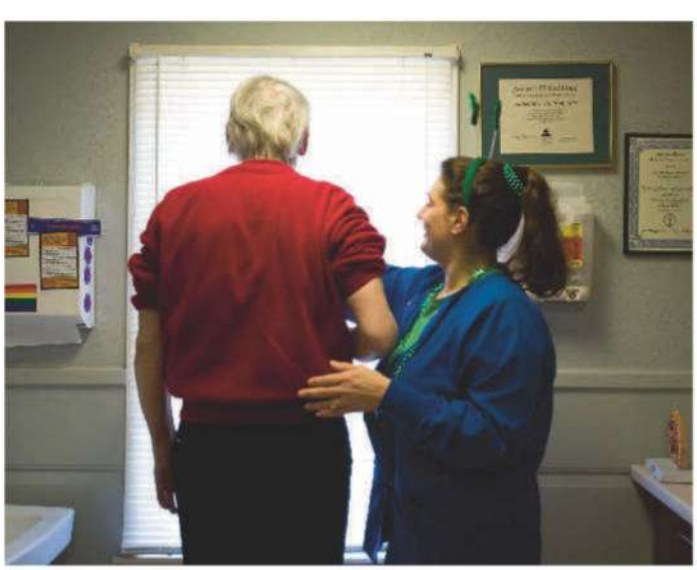
Still, the changing trend may reflect a real turning point in the country's obesity epidemic. More than half of adults in the US are eligible for semaglutide. As such, obesity rates will probably continue to fall as more of them start taking the drug.

"If one-third of our population uses [semaglutide], it will definitely reduce obesity," says Mozaffarian. "We'll also break the bank. We can't afford it. But we'll definitely reduce obesity." A year's supply of the drug for treating obesity costs more than $16,000 (£12,700) without insurance.

Newer, more potent weight-loss medications may drive obesity rates even lower, says Brownstein. One – tirzepatide, which is sold under the name Zepbound – was approved in the US and UK in November 2023. It can decrease body weight by up to 21 per cent.

We may have entered a new era in treating obesity, but we can't overlook that the recent decline in its prevalence may be partly, or even largely, due to the loss of hundreds of thousands of lives during the covid-19 pandemic. Such a tragedy underscores just how important it is to address the obesity epidemic. ▮

For more on the effects of Ozempic, see page 19



CHRISTOPHER CAPOZZIELLO/THE NEW YORK TIMES/EYEVINE

Maintaining a healthy weight helps reduce the risk of a range of illnesses

45%
Proportion of adults in the US who were considered obese in 2021

1%
Drop in proportion of adults in the US considered obese in 2023

1.7%
Proportion of the US population prescribed semaglutide in 2023

Palaeontology

Dinosaur highway

Giant footprint site showcases dinosaurs that wandered the UK

Eleanor Parsons

THESE stunning dinosaur tracks are just some of around 200 footprints uncovered in Oxfordshire, UK.

Five different sets of prints have been excavated at Dewars Farm limestone quarry, including the two shown crossing in the main image. These, along with two other sets, belonged to sauropods, possibly from the *Cetiosaurus* genus, which could be up to 18 metres long. The track running from bottom right to top left is from the larger of the two herbivores, with each footprint being 90 centimetres long.

A fifth set of fossil prints is from a large carnivorous dinosaur, thought to be a species of therapod called *Megalosaurus*. These impressions (inset) are slightly smaller, at 65 centimetres long.

All the tracks date to the middle of the Jurassic Period, around 166 million years ago. At this time, the area would have been a warm, salty lagoon along with mudflats. ▮

UNIVERSITY OF BIRMINGHAM; INSET: EMMA NICHOLLS/OUMNH

Artificial intelligence

AI helps avatars behave more like us

AN ARTIFICIAL intelligence model can make virtual avatars gesture naturally to match spoken words – possibly paving the way for AI-generated newsreaders or influencers that move more realistically as they speak.

As humans talk, we gesture to help convey our meaning. But when video game characters or digital avatars attempt similar behaviour, they often make generic movements regardless of what they are saying.

To make virtual figures gesture more realistically, Changan Chen at Stanford University in California and his colleagues first pre-trained their model on 1000 hours of audiobooks with accompanying written text and 60 hours of motion data showing people standing around and gesturing while talking. This process helped the AI learn how to decode the relationships between text, audio and video, says team member Ehsan Adeli, also at Stanford.

That initial training step enabled the AI to recognise the natural relationships between speech and certain movements – such as how people might tilt their heads before making a gesture with their hands – as well as how a specific tone of voice accompanies certain emotions.

Based on that knowledge, the AI learned how to perform new tasks, such as generating realistic gestures that matched speech, using fewer examples than similar models. Although other AIs have predicted body movements based on either written text or spoken audio, this model worked with both forms of input. It also learned to identify an emotion such as happiness from footage of a person moving, with or without audio (arXiv, doi.org/nznc).

The new training strategy helped the model outperform previously published AI models on a benchmark test. "Existing methods on co-speech gesture generation have unnatural motion that does not correspond to the speech," says Chen. In contrast, this model generated "more diverse and expressive human motion", he says. For example, when speakers emphasised certain words, such as "tired" or "because", the model generated more emphatic gestures for those words.

"It could make characters in video games or animated films gesture more naturally"

The research could lead to AI assistants or agents with realistic virtual avatars for interacting with humans, says Adeli. It could also make characters in video games or animated films gesture more naturally, he says. ▮

Jeremy Hsu

Quantum computing

Google's uncertain quantum future

The tech giant is racing ahead in building error-correcting quantum computers, but it may ultimately fall behind, finds **Karmela Padavic-Callaghan**

MANY researchers believe that the only way to build unambiguously useful quantum computers is to enable them to correct their own errors. A breakthrough in December from researchers at Google Quantum AI charted one path towards making this a practical reality. Their approach, however, may already be in danger of becoming outdated.

A big factor preventing quantum computers from living up to their promise – solving seemingly intractable problems in materials science, chemistry, logistics and many other fields – is that they constantly make errors. And as they get larger and gain more computing power, these accrue even more.

Last month, however, researchers at Google Quantum AI demonstrated that this doesn't have to be the case. Using a quantum computing processor called Willow, they showed that computations can be corrected by grouping qubits – the basic building blocks of any quantum computer – into so-called logical qubits, which can be made larger without negatively affecting performance.

Front-runner

The mathematical recipe the team used to group qubits is called the surface code, and it has long been the front-runner among quantum error-correction approaches. Here, qubits are arranged in two interwoven square grids, one consisting of data qubits, which are used for computation, and one comprising ancillary qubits, which can detect errors in their data qubit neighbours.

In 2023, researchers at IBM introduced a competitor – the QLDPC code – where each qubit is connected to six others, and all seven monitor each other for errors. This approach cuts down the overall number of necessary qubits, with IBM's team estimating that it could use only 288 qubits to achieve the same level of error correction that the surface code delivers with 4000 qubits.

Quantum computers have only recently broken the 1000-qubit barrier, and no 4000-qubit machines exist yet. But using QLDPC may allow researchers to make quantum computers useful without jumping over that engineering hurdle.

> **"Advances have turned error correction in quantum computing into a hotbed of innovation"**

"To me, that lower qubit overhead is hard to compete with," says Joe Fitzsimons at the start-up Horizon Quantum.

IBM researchers have also been designing their quantum computing chips to be suitable for the connections that the QLDPC code requires. Adding new connections between qubits is tricky because it creates new ways for qubits to be disturbed and new routes for their information to be lost. But the IBM team found that the redesign didn't change the reliability of logical operations that its chips can support, said IBM's Oliver Dial at the Q2B conference in Santa Clara, California, on 10 December. "Not all logical qubits are created equal," he said, underscoring that while they all protect calculations from errors, some are harder to make.

David Shaw at Global Quantum Intelligence, a UK business intelligence company, said at the conference that advances in the QLDPC code and similar mathematical recipes have turned error correction into a "hotbed of innovation".

Which approach will win out, enabling a useful quantum computer first, remains to be seen. "Maybe someone somewhere is working on a type of surface code that is really great, but right now there is competition [to the surface code]," says Yuval Boger at US-based quantum computing start-up QuEra.

GOOGLE

Quantum processors like Google's struggle to correct errors

Another ingredient that could tip the balance in favour of one approach is the physical make-up of the qubits – the way qubits are made constrains which codes they can be used for. Both the IBM and Google Quantum AI teams use qubits made from tiny superconducting circuits that are connected in a relatively fixed way. But others use ultracold atoms, which can be shuttled around and constantly reconnected to one another.

Boger says this may restrict the two companies to using codes that best match their hardware instead of codes that simply deliver the lowest error rates most efficiently. His team previously used a quantum computer with qubits made from extremely cold atoms that had one of the largest numbers of logical qubits yet, and he says the group is interested in trying different codes to reconfigure the logical qubits and make them more useful.

However, implementing the kind of connectivity that codes like QLDPC require may be a non-trivial engineering challenge for many existing quantum computers, says Shaw. For him, this is a reason not to write off the surface code just yet. Additionally, the details of how to use logical qubits created with QLDPC for full calculations is still less clear than for the surface code, which has been studied for over 20 years.

"The surface code is well understood, with a well studied theoretical framework. It offers a balance between performance and required qubit connectivity, making it well suited for superconducting qubits, and thus well suited for Willow," says Sergio Boixo at Google Quantum AI. But his team is exploring other quantum error-correction codes too, he says. ▮

Solar system

Pluto may have captured its moon Charon with a brief kiss

Alex Wilkins

PLUTO and its moon Charon may have been briefly locked together in a cosmic "kiss", before the dwarf planet released the smaller body and recaptured it in its orbit.

Charon is the largest of Pluto's five moons, with a radius more than half that of Pluto itself, but the question of how it came to orbit Pluto has puzzled astronomers.

One prominent idea suggests Charon formed after a vast object smashed into Pluto, spewing debris into space that later formed Charon, similar to how scientists think Earth's moon formed. But Charon's large size and close orbit, at just eight times wider than the diameter of Pluto, make this a challenging scenario to explain.

Now, Adeene Denton at the University of Arizona and her colleagues have proposed that Charon may have a less destructive origin story, which they describe as a "kiss and capture".

Previous simulations have treated Pluto and Charon as fluids – an assumption that works when modelling collisions between larger bodies. But recent research has shown that with objects of lighter mass than Earth's moon, the material strength of their composition influences the outcome.

How Charon (right) came to orbit Pluto has puzzled astronomers

HYPERSPHERE/SCIENCE PHOTO LIBRARY/ALAMY

"Pluto and Charon are quite small, so the assumption that they are fluid bodies probably no longer applies," says Denton.

The researchers ran simulations that take into account Pluto and Charon's compositions of rock and ice, finding that a more likely scenario involved a gentle sticking together and parting of ways.

Their model showed that a proto-Charon may have penetrated a proto-Pluto's icy shell and the two bodies would have spun together rapidly for around 10 hours. Eventually, the spinning flung Charon back out and it settled into Pluto's orbit (*Nature Geoscience*, DOI: 10.1038/s41561-024-01612-0).

"I had always assumed that any collision between planetary bodies that were hundreds of kilometres across would destroy the smaller one, if captured," says David Rothery at the Open University, UK.

While the kiss-and-capture scenario is interesting, it will need to also explain the complex geological features seen on both Pluto and Charon, such as heavily cratered surfaces and icy volcanism, which it doesn't currently, says Rothery. ▮

Technology

AI helps work out what someone is trying to say

PEOPLE who find it difficult to speak due to a stroke or Parkinson's disease could communicate more easily with the help of artificial intelligence. A new model constructs what a person is trying to say based on tiny vibrations in their throat, but also takes into account other factors, such as what time it is and the emotions they may be experiencing.

Some neurological conditions can result in dysarthria, where people lose fine control over their voice box, jaw or tongue. Previous solutions using brain-computer interfaces have yielded promising results, but users needed invasive surgery to place electrodes on or in their brains.

Now, a group of researchers – including academics from the University of Cambridge, University College London and Beihang University in Beijing – has used textile strain sensors to measure the movement of throat muscles, via vibrations, as well as the pulse in the carotid arteries, to shed light on whether a user's emotional state is neutral, relieved or frustrated.

That data is then fed into two large language models, each based on GPT-4o-mini, the model behind some versions of ChatGPT. The first, known as the token synthesis agent (TSA), aims to tease out the intended words mouthed by the user and group them into sentences.

The second, the sentence expansion agent, takes sentences from the TSA and uses contextual information like the time and weather, as well as the user's emotional data, to expand the sentences into what the researchers describe as "logically coherent, personalised expressions that better capture the patient's true intent", compared with when the sentences are created without contextual and emotional clues.

When the researchers tested the system in five people with dysarthria as a result of a stroke, their system achieved sentence error rates as low as 2.9 per cent.

"Users just do what they did before and magic happens. That's what good social interaction should be like"

They also found that using emotional and contextual clues to add to sentences increased user satisfaction over straightforward reconstruction of sentences by 55 per cent (arXiv, doi.org/nzv3).

Russell Beale at the University of Birmingham, UK, says the technology could be hugely positive. "[Users] don't have to think about doing anything differently," he says. "They just do what they did before, and magic happens. And that's what good [social] interaction should be like."

But he adds that interpretation of intended communication comes with risks. "It could be a bit frustrating for people if that language model is saying things in a way that they wouldn't," he says. ▮

Matthew Sparkes

Technology

Delicate robot hands know just how hard to squeeze

Matthew Sparkes

A ROBOTIC hand inspired by human skin can sense how hard an object is with a single digit's touch and work out how much force is needed to grip it before the rest of the hand closes its grasp.

Gripping an object firmly enough to secure it, but softly enough that it doesn't break, is something that humans learn as infants, but robots struggle with. Engineers have tried various techniques, including using cameras and artificial intelligence to identify objects, but each has problems. For example, relying on visual cues can't help with novel objects.

"If you have a robot chef, it's not going to be taught every single vegetable in the world," says Jonathan Aitken at the University of Sheffield, UK.

Anway Pimpalkar at Johns Hopkins University in Baltimore, Maryland, and his colleagues have developed a new technique that could be used in robotics or prosthetics. It involves piezoelectric sensors – essentially a microphone that converts tiny vibrations into electrical signals – embedded in the fingertips of the robotic hand. After touching an object with one digit, an AI model interprets these signals to estimate how hard it is within the 15 milliseconds it takes for the other fingers to close in on it.

Pimpalkar and his colleagues tested the system on a range of objects with varying stiffness, including apples, oranges, avocados and tennis balls. The team found that the best-performing model estimates the force needed to safely hold an object with over 98 per cent accuracy (arXiv, doi.org/nzhq).

This approach enables robots to learn about an object by touching it, but not destructively, says Aitken, and it works so quickly that it can make a grasp look like a natural, fluid motion. "It's the way our finger works," he says. ▮

Environment

Global treaty is failing to curb ultra-potent greenhouse gas

Madeleine Cuff

QILAISHEN/BLOOMBERG VIA GETTY IMAGES

Air conditioning units often use HFC gases

EMISSIONS of a powerful greenhouse gas are much higher than officially reported by governments, suggesting a global agreement to stamp them out is failing.

The gas in question is HFC-23, a byproduct of the process used to create HCFC-22, a refrigerant and a feedstock for some plastics. Emissions can be reduced by adjusting manufacturing processes and retrofitting factories.

Under the 2016 Kigali Amendment to the Montreal Protocol, more than 160 nations said they would do their best to eradicate emissions of HFC-23, a gas with 14,700 times more warming potential than carbon dioxide. Data provided by governments suggest emissions have fallen by more than 80 per cent since 2008. But analysis of atmospheric data paints a different picture, indicating that countries haven't succeeded in reducing HFC-23 emissions by as much as they claim.

A research team led by Ben Adam at the University of Bristol, UK, compared estimates of HFC-23 emissions based on atmospheric analysis with estimates based on "bottom-up" emissions data and policy action published by individual countries.

The researchers found that although HFC-23 emissions are falling, they remain well above reported levels and out of line with the Kigali Amendment.

In 2019, global HFC-23 emissions hit a high of 17.3 kilotonnes per year, the team found. By 2023, the latest year for which data is available, this had dropped to 14.1 kilotonnes per year. But that is still five

14,700

HFC-23 is this much more warming than carbon dioxide

times as much as the reported emissions based on information from national governments (*Communications Earth & Environment*, doi.org/nznz).

Tim Arnold at Lund University in Sweden says the research demonstrates that the Kigali Amendment "isn't working as well as it should be". "For some reason, it appears that these HFC-23 emissions are just not being abated at the rate they should be," he says.

China is a major global producer of HCFC-22, and therefore a major emitter of HFC-23. It claims to have virtually eliminated HFC-23 emissions by implementing abatement strategies. But this latest analysis used atmospheric data from a monitoring station in South Korea to assess the true scale of HFC-23 emissions in eastern China, where most of the country's HCFC-22 producers are located.

Estimates based on China's reported action suggest its emissions should be around 1 kilotonne per year. Atmospheric analysis indicates the emissions from eastern China were closer to 5.6 kilotonnes per year in 2023, with emissions having fallen by only 40 per cent since 2018.

These emissions make up around one-third of the global discrepancy between reported emissions and atmospheric observations. Russia and India are also major HCFC-22 producers, so HFC-23 emissions may well be continuing in these nations as well, says Arnold, but there is no nearby monitoring station to detect them.

"Russia and India could have a big impact on global HFC-23 emissions. But unfortunately, we just don't have the measurements in place to make those calculations," says Arnold. ▮

For more on refrigeration, see page 18

Quantum physics

Atoms bent in 'impossible' test

Diffracting hydrogen and helium atoms with a crystal was thought too difficult – until now

Alex Wilkins

A CLASSIC quantum experiment that shows how particles can behave like waves has been demonstrated with atoms for the first time, something that was thought to be impossible.

In 1927, George Paget Thomson showed that electrons passing through a crystal would diffract, producing a distinctive circular pattern that occurs when a wave squeezes through a small opening and then bends its path, spreading outwards. In this case, the pattern is caused by the electrons going through gaps in the crystal's structure, called a grating. This experiment, which won Thomson a Nobel prize, was a key piece of evidence showing that subatomic particles are partly wave-like.

A diffraction pattern for atoms was demonstrated a few years afterwards, but this instead involved reflecting atoms off a surface. Scientists later worked out how to diffract atoms through gratings, but these had to be specially designed. The gaps in these gratings were much larger than crystal gratings, which limited the sensitivity of the diffraction patterns.

Diffracting atoms through a crystal grating, as in the case of the electron, would allow for much larger, and so more sensitive, patterns, but it was thought to be impossible because the high-energy atoms required would damage the crystal grating so that diffraction couldn't take place.

"If I am clumsy, like a drunk teenager opening a door, then there will then be no diffraction"

Now, Christian Brand at the German Aerospace Center and his colleagues have diffracted helium and hydrogen atoms through a crystal grating in the form of a graphene sheet, a one-atom-thin layer of carbon atoms.

Brand and his team first accelerated hydrogen or helium atoms in a narrow beam to high speeds and energies because it had previously been shown that room-temperature hydrogen and helium couldn't pass through graphene. Then they fired the high-energy atoms at the sheet of graphene, which they thought should have been damaged.

However, after 100 hours of irradiation from the atom beam, Brand and his colleagues recorded no damage to the sheet. Instead, they observed the distinctive circular ring patterns produced from diffraction when they placed a camera on the other side (arXiv, doi.org/nzhj).

"It's brilliant work and I'm impressed the authors tried such an audacious experiment," says Bill Allison at the University of Cambridge.

Giving the atoms higher energies is what allows them to squeeze through the graphene gaps, says Allison, because they can exchange energy with the graphene's atoms in an undetectable way. If the energy exchange were detectable, then the wave nature of the atoms would be disturbed, by the laws of quantum mechanics, and the diffraction pattern would no longer occur.

This can be thought of as a room with many doors that are typically closed, but become open at higher energies. "I can only get through if I open a door, and that takes energy. If I am clumsy, like a drunk teenager, then everyone will know which door I used and there will then be no diffraction," says Allison. "If I open the door and then close it deftly without losing or gaining energy, then no one, including me, knows which door I used and therefore there will be diffraction." ▮

Archaeology

People ate lots of foxes and wildcats 10,000 years ago

FOXES and wildcats made up a notable part of people's diets 10,000 years ago in what is now Western Galilee in Israel.

When hunter-gatherers in the eastern Mediterranean Levant transitioned to sedentary life during the Neolithic revolution, they shifted from hunting large red deer to targeting smaller game, like gazelles.

The bones of red foxes (*Vulpes vulpes*) and African wildcats (*Felis silvestris lybica*) are also found in settlements in the region dating to this period. This has long been attributed to people harvesting fur and to symbolic associations like tooth ornaments.

Now, Shirad Galmor, then at Tel Aviv University in Israel, and her colleagues have found cut and burn marks typical of butchering and cooking on the bones, suggesting that foxes and wildcats became "food staples" during this period. "These clever and highly resilient people would never have wasted good, eatable meat, once in their possession," she says.

Galmor and her colleagues investigated the 10,200-year-old site of Ahihud in Western Galilee. They found that 32 per cent of the disassembled animal bones in household areas were gazelle and 12 per cent were red fox. Other small carnivores made up 4 per cent of the bones, including wildcats.

NSP-RF/ALAMY

African wildcats were hunted for their fur and meat in the early Levant

Leg bones – which are rich in meat – were common among fox and wildcat remains, says Galmor. Half of the knife marks seen on fox bones were related to butchering. In wildcats, 83 per cent of knife marks represented butchering. Other marks reflected skinning (*Environmental Archaeology*, doi.org/nzg6).

Burn marks on the carnivore bones were as frequent as those on deer bones, and more than half the burn marks affected the limbs.

The results provide strong evidence that foxes and wildcats were hunted and used for both pelts and cooked meat, says Galmor.

Foxes may have been particularly easy prey, says Bill Finlayson at the University of Oxford. "You have to wonder whether they're starting to scavenge around these increasingly sedentary settlements." ▮

Christa Lesté-Lasserre

Mathematics

Error found in decades-old proof

Researchers working to make maths machine-readable discovered a nasty surprise

Alex Wilkins

A MISTAKE in a proof underlying a widely used branch of modern mathematics was accidentally discovered by mathematicians while translating old proofs to a computer language. The problem was swiftly fixed, but the episode highlights the importance of making maths computer-readable to catch other possible examples.

Most modern maths resides in research papers and textbooks, and relies on mathematicians checking each other's work to make sure it is correct. A proof is essentially a social construct – if enough mathematicians are satisfied that the logical steps of a proof are correct, then it is considered true. On the rare occasions this process goes wrong, a proof can be left in limbo.

One way to avoid this is to check proofs step by step with a computer, but doing so involves translating them into computer-readable languages in a process called formalisation. This is a relatively new idea, and can be time-consuming.

Recently, Kevin Buzzard at Imperial College London and his colleagues began formalising the proof of Fermat's last theorem, which is important in modern maths. The proof employs many different cutting-edge branches of the subject, much of which isn't yet machine-readable, so these must be translated first.

> "The idea that a foundational result in maths may contain an error is nightmarish"

While working on translating one of these branches, known as crystalline cohomology, Antoine Chambert-Loir at Paris Cité University encountered an error. A part of an old proof that forms the foundations of crystalline cohomology, written in a paper by the mathematician Norbert Roby in 1965, appeared to contain a mistake. On closer inspection, Chambert-Loir found that Roby appeared to have forgotten a symbol between one line and another, invalidating the proof.

This would have been a major problem, wrecking many more recent proofs, if Roby's work were the only evidence for crystalline cohomology being correct, says Buzzard. However, it has been proven using so many strategies since that it was incredibly unlikely Roby's proof couldn't be fixed.

After Buzzard discussed the error with colleagues, Brian Conrad at Stanford University in California found a separate, later proof for what Roby was trying to prove, showing that Roby's error wasn't fatal after all. That makes this particular problem a fairly small one, but still a potential harbinger of larger, unknown errors that may be lurking in the mathematical literature.

It is surprising that such a widely used field as crystalline cohomology was originally dependent on such obscure and hard-to-find references, says Chris Birkbeck at the University of East Anglia in the UK, but formalising mathematics will help verify that the mountain of academic literature that now exists doesn't contain more mistakes.

"The idea that a foundational result may contain an error, that has then been used in thousands of subsequent works, is a nightmarish one," says Chris Williams at the University of Nottingham, UK. "Formalisation seems to give another lock on the validity of the foundations of our field that is very welcome." ▮

Climate change

Say goodbye to deep snow across the US if world warms

DAYS with snow on the ground are set to become less common across much of the continental US due to climate change, with deep snow almost everywhere but high mountain regions projected to go.

We have long known that warming temperatures can reduce snow cover, but the relationship isn't always straightforward. Higher temperatures can cause more snow to fall as rain, speeding up melting. But this heat can also boost overall precipitation by enabling the atmosphere to hold more water vapour, increasing snowfall.

Elizabeth Burakowski at the University of New Hampshire and her colleagues used a climate model to project how snow cover would change across the continental US under a worst-case emissions scenario leading to global warming of around 3.6°C by 2100.

SHUTTERSTOCK/JAMES KIRKIKIS

Areas like Woodstock, Vermont, may see less snow in the future

They found that the number of days each year with at least some snow on the ground will decline across much of the country. Areas like New England will still get snow, but "more ephemeral, come-and-go snow", says Burakowski, who presented the work at the American Geophysical Union meeting in Washington DC last month.

There will be a more dramatic decline in days with deep snow – a snowpack around 76 centimetres thick or more, enough to melt into the snow water equivalent of at least 75 millimetres of precipitation. By the end of the century, most of the country will have no deep snow days, save for mountainous areas like the northern Rockies and parts of Maine.

The loss of this deep snow can affect animals and plants and will also have consequences for water storage and flooding, says Burakowski. ▮

James Dinneen

Neuroscience

Blinking could give your brain a microbreak

Conor Feehly

BLINKING serves a crucial physiological function, by clearing debris from our eyes and keeping them lubricated, but now it seems it may also have a cognitive role.

In 1945, Arthur Hall at the University of Sheffield in the UK reported on the frequency of blinking as people read aloud, finding that it mostly coincided with gaps in the print. He suggested that blinking may help people take pauses as they read.

To expand on this idea, Louisa Bogaerts at Ghent University in Belgium and her colleagues analysed data gathered previously for the Ghent Eye Tracking Corpus study, in which 15 people were monitored as they silently read an Agatha Christie novel across four sessions, collectively blinking 30,367 times. "The results clearly show that we do not blink randomly when reading," says Bogaerts.

The team found that the participants were less likely to blink after reading words that frequently occurred in the text compared with those that occurred infrequently. This "suggests that cognitive effort influences blinking behaviour", says Bogaerts.

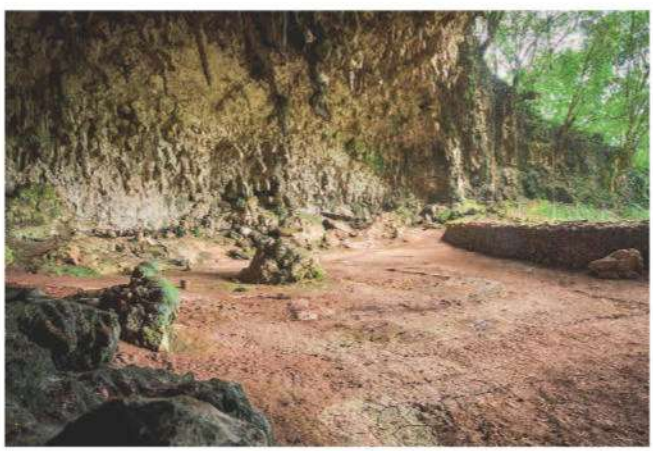
Blink rates were 4.9 times higher at any punctuation marks, on average, compared with other positions in the text. They were also 3.9 times higher at the end of a line on a page and 6.1 times higher when punctuation and line endings coincided (PsyArXiv, doi.org/nx9s).

"Increased blinking at punctuation marks and line endings likely reflects that these are natural attentional breakpoints; we align with these breakpoints in the text and take a break to blink," says Bogaerts. "Together, these findings support the hypothesis that blink timing during reading is not random, but strategically aligned with the cognitive demands posed by the text."

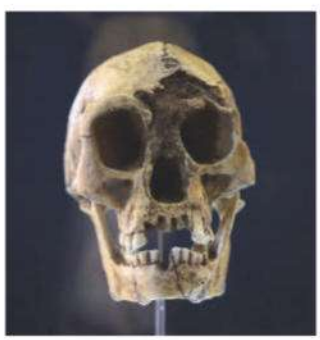
Human evolution

Climate change may have killed ancient 'hobbit'

Christa Lesté-Lasserre



RAFPRO/ALAMY; LANMAS/ALAMY



***Homo floresiensis* was found in Liang Bua cave on the island of Flores**

SEVERE drought caused by climate change may have led to the decline of Indonesia's pygmy elephants and the "hobbit"-like humans who hunted them.

Until about 50,000 years ago, *Homo floresiensis*, standing about a metre tall, thrived on the South Pacific island of Flores by consuming meat from dwarf pachyderms called stegodons.

Researchers originally thought that *H. floresiensis* – whose bones were discovered in Liang Bua cave in 2003 – died out as recently as 12,000 years ago, possibly because of volcanoes and competition with much larger *Homo sapiens*.

More recent studies, however, suggest that both *H. floresiensis* and its primary prey, *Stegodon florensis insularis*, went extinct about 38,000 years earlier than that – and that modern humans only arrived about 4000 years afterwards. Evidence for catastrophic levels of volcanic activity is also lacking, says Michael Gagan at the University of Wollongong in Australia.

Instead, he and his colleagues wondered whether the hominins were victims of climate change, given that most of the annual rainfall in this region comes from summer monsoons – meaning altered weather patterns could have a big impact on survival.

To find out, the researchers took rock samples in a cave 600 metres away from Liang Bua, choosing this location because the rocks had already been precisely dated. They examined

51%

Flores was this much drier 56,000 years ago than it is now

the ratios of magnesium to calcium and of different oxygen isotopes within the rocks, which can provide information about historical seasonal rainfall patterns, says Gagan.

The analysis revealed that the average annual rainfall in the area dropped by 38 per cent between 76,000 and 55,000 years ago, and around 56,000 years ago the climate was 51 per cent drier than today (Earth arXiv, doi.org/nznw).

Reduced summer rainfall may have initially led to conflicts over the scant available water, says Gagan. As the climate continued to turn dry, resources probably dwindled so low that the stegodons – which, like modern elephants, needed lots of water – abandoned their homelands in search of water, perhaps along the greener coastal areas, he says. Then, *H. floresiensis* may have done the same, in pursuit of their prey.

Alternatively, if the stegodons had stayed, their population levels would have dropped significantly due to the lack of water, he says. *H. floresiensis* could have overhunted them to extinction and then moved elsewhere to find food.

Both species would probably have been more vulnerable once outside their native lands, especially if they crossed paths with modern humans, says Gagan. That might have happened, since *H. sapiens* are very likely to have travelled along the island's coastlines in boats en route from Asia to what is now Australia and its nearby islands, where they arrived at least 60,000 years ago.

The findings make sense, since water availability is a main driver of change for humans and animals, says Michela Leonardi at the University of Cambridge.

Zoology

Dolphins may use their teeth to hear underwater

Taylor Mitchell Brown

A STUDY of dolphin jaw anatomy suggests their teeth might act as antennae for sound waves, potentially helping explain how they hear and use echolocation underwater.

"Our findings support the hypothesis that dolphins utilise their teeth as part of an advanced sound reception system," says Ryo Kodera at Tsurumi University in Japan.

Scientists have long known that dolphins and other members of the toothed whales group of species, also known as odontocetes, have unique teeth, many of which aren't used for chewing. The reason they have so many of them is a mystery.

Many researchers have hypothesised that dolphin teeth are well-suited to receive sound waves, says Kodera. The dolphin cochlear nerve – a vital part of the inner ear that processes auditory stimuli – connects to fat in the mandible, or lower jaw, of the dolphin, suggesting that their teeth might act as an interface between sound vibrations in the water and the pathway to the brain.

To better understand dolphin teeth and their relationship to the jaw, Kodera and his team investigated mandibles from several odontocete species, including the common bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) and false killer whale (*Pseudorca crassidens*). They also examined the jaws of domestic pigs (*Sus scrofa domesticus*) as a comparison.

They identified several unusual features in odontocete jaws. The teeth sit more loosely within the jaw than in other mammals, and the alveolar sockets, which hold the teeth, are spongier and more porous than those in land mammals. Most importantly, they found that long and thick bundles of nerve fibres connect to the teeth through these porous structures.

"These long fibres indicate significant tooth mobility, while the thick nerve bundles suggest heightened sensitivity to tooth movement," says Kodera.

JEFF MONDRAGON/ALAMY

Bottlenose dolphin teeth are unlike those of many mammals

"Dolphin teeth sit more loosely within the jaw than they do in other mammals"

The nerve bundles in dolphins had many sensory receptors at their ends and were wrapped in a thick layer of fatty insulation, which helps electrochemical signals travel more quickly through nerve fibres. The fibres are thicker than those in land mammals, suggesting the teeth might have a sensitivity comparable with that of tactile hairs used by some animals to sense touch, says Kodera (*The Anatomical Record*, doi.org/nx8b).

Philippe Blondel at the University of Bath, UK, says the results don't necessarily show which senses the fibres might aid. "This would need to be borne out from other studies."

Kodera acknowledges that the findings aren't conclusive evidence of a direct role for the teeth of dolphins in echolocation or underwater hearing. "Future research should focus on direct physiological and biomechanical studies," he says.

The results are eye-opening, says Robert Boessenecker at the University of California Museum of Paleontology in Berkeley. He would like to see the nature of the fibres tested in living dolphins next. "I will certainly have this study in mind any time I'm looking at dolphin mandibles and tooth sockets," he says. ▮

Technology

Crystal-based cooling could make fridges sustainable

Karmela Padavic-Callaghan

A NEW type of crystal could enable refrigerators and air conditioners to keep us cool without warming the planet.

Refrigerators and air conditioners get their cooling power by circulating a liquid, which absorbs heat and causes chilling through a cycle of evaporation and condensation. But many such liquids contribute to the greenhouse effect, causing warming when they leak. Now, Jenny Pringle at Deakin University in Australia and her colleagues have made a climate-friendly alternative to these liquids using "plastic crystals" – crystals with molecules that can move just enough to make them pliable.

Under sufficient pressure, the molecules in these plastic crystals go from being randomly oriented to aligning themselves into a neat grid. Then, when pressure is removed, they become disordered again. As part of this disordering process, the crystals absorb heat, effectively cooling their surroundings.

Such pressure-based cooling has been investigated before, but most materials tested could only do so at balmy temperatures, limiting their cooling power, says Pringle. In contrast, the heat-sucking ability of her team's crystals kicks in at temperatures from -37°C (-34.6°F) to 10°C (50°F), a suitable range for household refrigerators and freezers (*Science*, doi.org/nzm3).

However, the crystals aren't ready to leave the lab yet. That's because the pressures needed are too high – hundreds of times greater than atmospheric pressure and equivalent to being thousands of metres underwater, says Pringle.

David Boldrin at the University of Glasgow, UK, says materials like those in the new study have "the potential to almost completely decarbonise this huge [cooling] industry", but he shares the concern about the high pressures required. ▮

Medicine

Ozempic has heart health benefits

Treatments containing semaglutide may aid the heart even without any weight loss

Michael Le Page

THE active ingredient in Ozempic and Wegovy, a drug called semaglutide, can have direct beneficial effects on the heart within weeks, in addition to the longer-term benefits of losing weight, an animal study has shown.

This finding suggests that people with heart disease who don't have type 2 diabetes or obesity, which semaglutide is primarily used to treat, might also benefit from taking this kind of drug. "It may be that we're missing a large population of people that could benefit," says Christopher Stone at Brown University in Rhode Island.

The work also shows that people undergoing heart surgery could benefit if given GLP-1 agonists, the class of drugs that semaglutide belongs to, for at least a few weeks after their operation.

GLP-1 agonists were initially developed as a treatment for type 2 diabetes, but turned out to lead to weight loss as well. They have also been found to reduce the risk of heart attacks and strokes, which is expected when people lose weight.

But some of the cardiovascular benefits kick in even before people lose weight, says Stone, which suggests that these benefits aren't just a result of weight loss. To help confirm this, his team has looked at the effect of semaglutide on the hearts of pigs.

"We're going back to animal models to try to figure out the mechanism," says team member Frank Sellke, who is also at Brown University. Animal studies usually precede human ones, says Sellke. "So it's kind of backwards, in a way."

The team placed rings around one of the arteries supplying the heart in 17 pigs, reducing blood flow, as occurs in heart disease. Eight of the pigs were given an oral form of semaglutide after the procedure, while the others weren't.

After five weeks, the team found clear differences between the two groups. In those given semaglutide, there was "markedly improved" blood flow to the affected area of the heart, both at rest and under stress, which suggests that other coronary arteries had sprouted new connections. There was also "markedly reduced cell death" in the heart muscle and less scarring (*Arteriosclerosis, Thrombosis, and Vascular Biology*, doi.org/nx79).

There have already been a number of studies looking at whether giving people GLP-1 agonists after heart surgery is beneficial, with some showing little or no benefit. But these involved giving the drug only as a single dose or several times over just a few days, says Stone. "We have good evidence that a longer duration of drug may be needed than has been currently studied."

"I think it is clear that weight loss almost always helps the heart," says Randy Seeley at the University of Michigan. "Nevertheless, I would say that this study adds to a growing body of evidence that there is another mechanism by which GLP-1 agonists improve cardiovascular endpoints that is beyond weight loss." ▮

Archaeology

Ancient dress had a striking pattern for its time

LEIDEN UNIVERSITY; HANNA GEELS

Remnants of ancient fabric preserved under metallic jewellery allowed researchers to recreate Iron Age fashion using modern fabrics

A 2800-year-old red and blue checked dress found in an Early Iron Age grave in the Netherlands might be the oldest double-colour woven garment in Europe.

The skeleton of the elite individual who once wore this striking outfit had completely decayed due to harsh, sandy soil. But through mineralisation underneath metallic jewellery, remnants of the much-decayed wool dress provide evidence that the dyed textiles came from clothing, says Karina Grömer at the Natural History Museum, Vienna.

Ancient textiles are "rarer than gold" since they decay so easily, she says. And even when they are discovered, it isn't always clear what purpose they served – as many appear to have been used to wrap grave goods or to be gifts themselves.

In 2015, Grömer and her colleagues studied textiles found in an 8th century BC grave near Uden in the Netherlands that had undergone a natural conservation process through association with metals. Their positioning under bracelets and anklets suggested that the textiles once formed part of a long-sleeved dress, or perhaps a long-sleeved top with an ankle-length skirt. Grömer recognised a chequered pattern of two shades, but lacked the technology to investigate further.

Now, working with Loïc Bertrand at the University of Paris-Saclay, Grömer and her colleagues have performed high-resolution 3D imaging on 10 fragments from the four layers of fabric, measuring about 1 square centimetre each. They determined that the weave represented a classic eight-thread plaid formation known today as "shepherd's check" – which required considerable skill to produce, says Grömer (*Journal of Archaeological Science*, doi.org/nx78).

Molecular analyses revealed that the individual threads had been dyed prior to weaving. The blue dye probably came from a bush called dyer's woad (*Isatis tinctoria*) while the red came from Polish cochineal insects (*Porphyrophora polonica L.*). "This is such an extraordinary find," says Bertrand. ▮

Christa Lesté-Lasserre

New Scientist

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Culture columnist
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Comment

Children are more than the future

We need to stop ignoring the views of young people on artificial intelligence. They are already at the sharp end of its development, says **Mhairi Aitken**

NEXT month, world leaders will gather in Paris for the AI Action Summit, the latest in a series of high-profile international events on artificial intelligence. Previous ones have brought together heads of state, senior policy-makers and CEOs of tech companies to discuss how to tackle the risks of advanced AI technologies. But there is one group that has so far been entirely missing from these processes, and it happens to be the one that will be most affected by advances in AI: children.

Children are consistently the most underrepresented group in decision-making processes relating to AI's design, development and deployment, as well as the regulatory discussions and policy-making around how it should be used. That must change.

That's why, on 4 February, ahead of the Paris meeting, my team at the Alan Turing Institute in London has partnered with Queen Mary University of London to convene the Children's AI Summit. Supported by the LEGO Group and charitable organisation Elevate Great, it will bring together children aged 8 to 18 from across the UK to share their views on what should be on the agenda in Paris. It's a really exciting event, but also one that is long overdue.

Part of the problem is the way children are viewed in these spaces. When the importance of bringing children into these conversations is raised, it is often with reference to the familiar idea that "children are the future". That's something I fundamentally disagree with.

ADRIÀ VOLTÀ

If we value children because we view them as the future, we are seeing their worth only in terms of their potential, or what they might contribute in years to come. We focus on educating them so they are equipped to work with AI in the future or solve the problems that previous generations hand down, rather than facilitating their involvement in processes to address those problems today.

Children aren't the future. Children are the here and now.

In relation to AI, children of all ages already experience its effects on a daily basis. Babies and infants play with smart toys, very young children interact with smart devices, AI on social media filters the information teenagers access. In education, AI is used to personalise material or tailor learning pathways.

There are huge opportunities to use AI in positive ways, creating new, playful, fun experiences, or to support children in education through assistive technologies, for example. But there are also significant risks and as yet unknown impacts.

Getting this right means putting children at the heart of decision-making. Very often, problems occur because systems haven't been designed with children's needs and interests in mind, or because assumptions are made based on adults' experiences and perceptions.

No adult today has firsthand experience of being a child in a world with generative AI: children really are the only experts in this. To fully understand their experiences with these technologies, or what impacts they might be having, we absolutely must involve children themselves.

That's why the Children's AI Summit is so important. At the event, children will share their experience of AI and what matters to them when thinking about its future, including laying out what they want to see on the agenda in Paris. From the summit, we will produce a children's manifesto for the future of AI, and aim to share their messages with world leaders at the Paris AI Action Summit.

For too long, children's experiences, children's voices and children themselves have been overlooked in discussions around AI. I hope our summit is the beginning of many more activities that put children at the centre – valuing them not as future adults, but as the here and now. ▮

Mhairi Aitken is senior ethics fellow at the Alan Turing Institute in London

This changes everything

Back to the future Sticks found in a cave that date back 12,000 years show people of that time already had a conception of history and the future, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest book is *Stories Are Weapons: Psychological warfare and the American mind.* They are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading
Women in the Ancient Mediterranean World, *a fascinating survey by Guy D. Middleton.*

What I'm watching
The People's Joker, *a satirical movie about a dark future where all comedy is controlled by the US government (which is controlled by Batman).*

What I'm working on
Taking more walks.

This column appears monthly. Up next week: Rowan Hooper

A RECENT discovery in Cloggs cave, Australia, revealed something extraordinary about humanity's relationship with time. Several metres into the limestone grotto, archaeologists working with the Gunaikurnai Land and Waters Aboriginal Corporation found telltale signs of an ancient ritual: two ceremonial sticks covered in animal fat and highly specific burn marks. Here is the amazing part. The sticks were 12,000 years old, and they were almost identical to ones used for rituals in the late 19th century by local mulla-mullung, or sorcerers.

That means the GunaiKurnai people are the inheritors of what researchers called the "oldest-known culturally transmitted ritual", one practised continuously for 10,000 years before the Julian calendar even began.

For archaeologists, the cave ritual also suggests that people 12,000 years ago already had a conception of history and the future. When humans return to the same place to do the same things time after time, we can hypothesise that they are maintaining a record of past deeds and are planning to do them again on a day that has yet to happen.

It is exactly what we do in the modern world when we rely on past experiences with, say, train schedules to figure out how early to leave for the station. Despite grandiose claims to the contrary from professional prognosticators and tech executives, there is nothing fancy about predicting tomorrow. We have been doing it since the Stone Age.

Yet currently it seems impossible to think about the future, at least beyond the horizon of your next cup of tea. There are a lot of reasons for this: political instability, the rapid pace of scientific progress and climate chaos, to name a few. But with a better understanding of where our idea of the future comes from, it can be easier to start planning for what comes next.

Cloggs cave offers a good origin story of how humans discovered "the future". If we remember doing a ceremony in the cave yesterday, or 50 years ago, we can start to imagine doing it years from now. This is the foundation for a so-called cyclical view of time, where tomorrow is cast as a version of yesterday. It is ideal for human endeavours like farming and nomadic travelling, both of which require people to repeat year-long cycles so they have adequate food and shelter.

"You simply can't create massive projects like the Valley of the Kings without a strong sense of linear time"

Perhaps you were taught in school, as I was, that older civilisations thought cyclically about time, but the post-Enlightenment world has converted to a more linear concept, where the future accelerates rapidly away from the past. Problem is, it just isn't true. Indeed, the engineers who worked in Egypt 4000 years ago would laugh if they heard you suggest they couldn't imagine a future of major change. Have you seen their pyramids, miles of paved roads and giant palaces? You simply can't create massive, multi-generational projects like the Valley of the Kings without a strong sense of linear time and the ability to foresee a coming world that looks very different from the present.

Humans have always viewed the future in both cyclical and linear ways. We know the daylight will return as it has for millions of years, and we also know it will illuminate wild new stuff that never existed before – like the Great Pyramid of Giza.

Still, people living in the past few centuries have really become obsessed with the wild new stuff. We can blame H.G. Wells for popularising the notion that the future will be incomprehensibly alien, totally unlike our world now. Though his novel *The Time Machine* was fantastical, it reflected a broader cultural view during the industrial revolution that history hadn't prepared us for what was coming next. Eventually, we might evolve into competing post-human species of underground Morlocks and surface-dwelling Eloi. Echoing Wells, futurists today declare that humans are either on the brink of becoming hyper-evolved cyborgs or paper clips on the desk of a godlike AI.

Stories of a radically different future reassure us that humanity will continue making progress. But maybe we should consider that not everything needs to change. I am not suggesting that innovation is bad – I am a big fan of modern medicine and space flight – but we ignore the importance of cyclical stability at our own peril. Our environment, for example, would be in better shape if we had focused on sustainable agricultural practices inspired by the past.

When our visions of tomorrow come unmoored from history, the future becomes indistinguishable from a fantasy like *The Time Machine*. And that can have dire consequences. Catch my column next month to find out how the future was mutated in the 20th century and beyond. ▮

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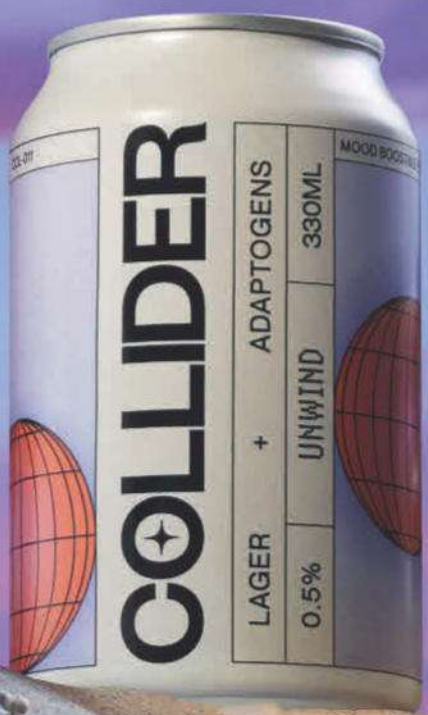

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Marble marvel

Photographer **Alessandro Gandolfi**
Agency **Panos Pictures**

AT THE foot of striking marble quarries in central Italy's Apuan Alps sits the village of Colonnata (top, far left) – a quaint place famed for its pork lard and quarry workers. The stone extracted from outside the nearby city of Carrara, including from the white marble quarry in the top, near-left image, is widely regarded as the purest and most valuable in the world.

Before modern technology, enormous blocks of marble were transported down the mountainside manually with cables, ropes and a sled in a method known as "lizzatura", as recreated in the bottom, far-left image.

"Since the time of the Roman Empire, the marble was considered the best in the world," says photographer Alessandro Gandolfi, who documented the story of the highly sought-after material in his project *Land of Marble*. "The best sculptors in the world, like Michelangelo, came personally to choose these marbles for their sculptures."

Several centuries after the Italian Renaissance, marble remains a staple material for artists. In the bottom, near-left image, students at Carrara's Academy of Fine Arts first hone their sculpting skills on clay.

Beyond its use in art, Carrara's marble is often pulverised and used as calcium carbonate to make products such as paper, paint, fertiliser and toothpaste.

But the extraction of marble isn't without impact on the environment. "We are extracting a little bit too much marble today," says Gandolfi. "If we keep going at this rate, you will see the mountains totally destroyed in 500 years' time."

Chen Ly

Editor's pick

Time travel may be fit for machines only

14/21 December 2024, p 54

From Beverley Rowe, London, UK

None of the methods of time travel discussed holds any hope for objects like human bodies to be able to do it. And why travel in time anyway?

Even assuming it were possible, the dangers would be enough to make it unthinkable: diseases to which one had no immunity, for instance. Not to mention the risk of being involved in complex and probably fatal social situations. Above all, the logical puzzles of doing something like causing the death of one's own grandfather is enough to stop the enterprise.

A better bet would be information transfer. Isn't this more likely to be possible? One can imagine miniaturisation reaching a point where we can make cameras that are small enough to go through a wormhole and transmit data.

This would also address an issue often raised by sceptics. If time travel is possible, people at some point in the future will achieve it. So where are they? Well, if tiny cameras have already been sent back to see what we are up to, we may be surrounded all the time by hundreds of them.

From Peter Waller, Alveston, Gloucestershire, UK

We don't have to go to the past, we just need to send data to the past. Perhaps 2025 will be the year that I get the message I am hoping to send to myself with the names of the Grand National horse race winners for the next 10 years.

Also time to ditch the pink and blue nonsense

14/21 December 2024, p 62

From Sam Edge, Ringwood, Hampshire, UK

I enjoyed your take on the worthiness of toys and especially agree with the advice to make sure kids have access to all types of toy, not just those traditionally associated with biological sex. My 5-year-old granddaughter is going through a unicorn and Barbie phase, but still enjoys dinosaurs, trucks, diggers, marble runs, farm animals and the rest that she owns. She likes to see motorbikes, cranes and aeroplanes.

In the same vein, it is unlikely that a preference for pink or blue is genetic in any way. Up until a century or so ago in Western culture, blue was associated with girls and pink and red with boys. How this swapped is an interesting historical tale for another day.

Not-so-invisible gorillas: another explanation

23 November 2024, p 12

From Derek Bolton, Sydney, Australia

Ian Phillips considers distrust of one's senses to be the most likely explanation for subjects denying having seen anything unusual in a video despite an unexpected object popping up, even if they could nevertheless convey some details of it. Alternatively, could it be to do with the phenomenon of blindsight? Visual processing involves many layers and brain regions. In blindsight, damage to one area can result in not being aware of any visual image yet still being able to guess the colours and locations of objects correctly.

Fate of polar ice should worry us all

7 December 2024, p 8

From Andrew Benton, Flourtown, Pennsylvania, US

Your story "Antarctic ice is at a crisis point" should be a five-alarm wake-up call for the entire planet.

The fact that Earth is warming at a worrying rate shouldn't really be a big surprise, though: 3 million years ago, when carbon dioxide in the atmosphere was at 400 parts per million, the world was 3 to 4°C warmer than now and sea levels up to 24 metres higher. There is no practical way to pull excess CO_2 out of the atmosphere, so this is where we are taking our planet.

However, we are now beyond 400 ppm, and emissions haven't declined despite big investments in wind and solar, so atmospheric CO_2 looks set to be far higher by the end of the century.

I fear there may be more to the upsides of a scare

7 December 2024, p 12

From Robert Masta, Ann Arbor, Michigan, US

A study of haunted house visitors showed that of 22 people with elevated inflammation, 18 had reduced levels three days after getting a good scare at the fairground attraction. But there was no control group of people with inflammation who didn't visit a haunted house. Would they have improved in three days, regardless? It is telling that the original paper notes that seven people without inflammation before the event had acquired it three days later. Maybe just a "three-day bug" going around?

Could alien tectonics be closer than we think?

7 December 2024, p 38

From Jim McHardy, Clydebank, West Dunbartonshire, UK

Instead of looking for evidence of tectonics on distant exoplanets, wouldn't it be easier to look instead on Mercury? While not tidally locked, it experiences a very large temperature range of more than 600°C from its day to night side, and its day side remains in sunlight for many Earth months at a time. This compares with the suggestion that tidally locked exoplanet LHS 3844 b has a sunlit-to-dark-side temperature range of 770°C, and is expected to exhibit tectonic movement.

Tectonic movement on Mercury, if it occurs, should be from equator to cooler poles. A very precise scan of Mercury's surface compared with a future scan will show any movement. A lander that could detect "mercuryquakes" would also be an ideal way to investigate.

To tame urban heat, cut vehicle numbers

23 November 2024, p 36

From Peter Jacobsen, Port Townsend, Washington, US

The first step in reducing urban heat should be to reduce the burning of fuels. All of the energy used in vehicles eventually ends up as heat. Some of the fuel's energy is used for propulsion, which becomes heat through mechanical, air and tyre friction. Most is wasted directly as heat. A study of Beijing determined that vehicles raised the city's temperature by over 1°C.

Kids will get round any ban on online activity

Letters, 14/21 December 2024

From Matthew Stevens, Sydney, Australia

A decade and a half ago, when my son was in year 7, the government in New South Wales, Australia, issued laptops to students with safeguards to prevent them freely roaming the internet. Within a week, he and all of his friends had bypassed these and spent their time watching videos in class.

Likewise, the Australian government's legislation to block children under 16 from using social media is doomed to fail. Children will find ways around the prohibition and share them. Instead of a ban, society must drive responsible use of social media.

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The man who loved animals

In the centenary of naturalist Gerald Durrell's birth, a new memoir adds rich new layers to what we know about the man, finds **Chris Simms**

Book
Myself & Other Animals
Gerald Durrell
Viking

VICTOR WATTS/SHUTTERSTOCK; BELOW: MIKE FLOYD/DAILY MAIL/SHUTTERSTOCK

Gerald covered in lemurs, and below with Lee Durrell – and an owl

THE conservationist Gerald Durrell's first dog, Simon, was a coward. To the honey-coloured cocker spaniel, a garden hose was as deadly as a spitting cobra, and he once went into a nervous decline lasting several days after unexpectedly encountering a snowman.

It is nuggets like this that make Durrell's writings so appealing. Anthropomorphised as his descriptions of animals often are, they combine keen observation with humour in a way that shows just how well he could understand what made animals tick and how to bring them to life on the page.

This is what made *My Family and Other Animals*, the book he is most famous for, a joyful account of his chaotic early life when his family moved to their new home in Corfu. The book, chock-full of escapades from a childhood spent with geckos, sea slugs, toads and butterflies, revealed the secret behaviours of animals in a way that captivated and inspired a generation of people to appreciate the natural world. It made a deep impression on me, leading me to my own adventures with hawks, newts, turtles and dolphins and to study zoology.

"Gerald Durrell's escapades with geckos and toads in his youth inspired a generation to appreciate nature"

Durrell wrote some 40 books, including many that were autobiographical. Sadly, he died in 1995, so what should we make of this posthumous work, *Myself & Other Animals*, released to celebrate the centenary in 2025 of the great conservationist's birth? Is another book really needed?

This time, it is an unpublished memoir that Durrell started. It includes letters to members of his family as well as extracts from previous books and from an unfinished book on a trip to Australia. *Myself & Other Animals* paints a picture of a large chunk of Durrell's life, with snapshots tied together with notes by his widow, Lee Durrell, who also put the book together.

Reading it makes you feel like an archaeologist uncovering an ancient mosaic. As you leaf through a section, you reveal the colourful sparkle of a new fragment. It isn't a complete picture, but by the end, you can see enough to feel you know Gerald Durrell just that bit better.

The book ranges from some of the highlights of his early days in India, England and Corfu, to his expeditions across the world to collect animals for zoos, to his battle to create his own zoo, which he finally managed to set up on Jersey in the UK.

It also talks about his drive to transform zoos from circus-like places where you pay to see exotic captives into more serious venues that encourage education, scientific observation and the breeding of rare animals in environments that are right for each species. There is still a considerable journey to make along that path, but the efforts of Durrell and others have yielded conservation successes, such as the breeding and release of the California condor and the golden lion tamarin.

His letters to his mother are among my favourite bits, rolling back time beautifully to the days before we could all instantly message each other with news.

I especially loved one from an expedition to Cameroon in 1949, sent care of a local branch of Barclays Bank. It reads: "Dear Mother, just a short note to let you know of some interesting things which have happened since I last wrote. Firstly, a thing that will shock you to the core, I was bitten by a snake." He goes on to explain – in detail that must have been excruciating for his mother, Louisa, to read – of a haphazard race to find a doctor with serum to counteract the potentially lethal venom.

Myself & Other Animals earns its place in the pantheon of Durrell's books, and will hopefully make more people dig out his back catalogue – of which *A Zoo in My Luggage* is another favourite.

But, troublingly, the new memoir also shows how little has really changed. Decades after parts of this book were written, endangered species he mentions are still in trouble and we are still losing the battle to protect biodiversity. As Durrell said, "so-called human progress moves at the speed of an Exocet missile, whereas conservation moves at the pace of a donkey and cart".

It may well be time to strap a green-energy-powered engine to that cart.

Chris Simms is a writer based in Somerset, UK

Chocolate's dark heart

Could reviving wild cocoa produce great chocolate ethically? **Jason Arunn Murugesu** explores a nerve-racking tale

Book

Wild Chocolate

Rowan Jacobsen

Bloomsbury Publishing

I THOUGHT I knew the basics about the chocolate industry. Most comes from hundreds of thousands of small cocoa farms in Ghana and Ivory Coast. Many of these use child labour – a truth well hidden in the exquisite confections a lot of us are working our way through this January.

Rowan Jacobsen's new book *Wild Chocolate: Across the Americas in search of cacao's soul* doesn't tell this story in detail. Instead, Jacobsen, a science writer, spins a narrower tale – one for which the author has put himself in the crosshairs for well over a decade. It is a story of wild chocolate, a product that, as its name suggests, attracts danger and adventure.

Deep in some of the world's most remote rainforests in South and Central America, wild cocoa trees with beans of all different shapes and colours grow. If expertly harvested, the beans can be used to make the world's best chocolate.

It is a subset of these trees that was brought to West Africa by European colonisers. Following independence from British rule, Ghana invested heavily in its cocoa production, and Ivory Coast quickly followed suit. Now, most of the chocolate we eat comes from this strain of West African trees – bred to be robust and yield large quantities of cocoa beans that, according to Jacobsen, make chocolate with a "fudgy, astringent flavour".

The original cocoa strains of Central America were left behind, so Jacobsen thought, until he tasted a chocolate bar called Cru Sauvage, which its maker claimed was the first made entirely from wild cocoa that grew in the Bolivian rainforest.

"It melted like silk," writes Jacobsen. "The flavor dove into a deep, dark place, and then, just when I thought I had a handle on it, the bottom fell out and it dove some more." Soon after this first mouthful, Jacobsen flew to the Bolivian jungle to meet Volker Lehmann, the eccentric German agroforestry expert behind Cru Sauvage. He found him at the landing strip, alongside four gun-toting men. The explanation is simple, if stark: the Bolivian rainforest may be an excellent location for rare cocoa plants, but it is also a prime spot for illegal drugs manufacturing.

Reading through this often nerve-racking story, we sweat alongside Jacobsen as he travels into the hearts of Central American jungles dripping with humidity and black flies. This is a world where "cocoa detectives" exist and experts wax lyrical, describing chocolate as a "symphony orchestra".

We meet people with big dreams who believe they can protect the rainforest by turning ancient strains of cocoa trees into a valuable commodity. We know of 10 or so families – or genetic clusters – of cocoa, but Jacobsen expects there are many more to discover: the latest grouping to be found, the Juruá, is the first with fully red seed pods, for instance.

Saving them isn't easy. The trees are in some of the world's most remote places, where setting up effective methods to dry and ferment the beans is no mean feat. So, while *Wild Chocolate* opens up a new world of ancient and fantastical cocoa trees that are just waiting to be harvested, it is also obvious that there is no guaranteed way to monetise these plants – the economics are too finely balanced.

If I had any criticism, it is that I would have liked to hear more from the Indigenous peoples who harvest wild cocoa. They could help with questions, such as how difficult is it to pick the pods? What happens during severe floods, like those that hit Bolivia in 2019? And will climate change destroy this enterprise?

The book has changed the way I look at chocolate. I think it will do the same for a lot of readers. ▮

Most chocolate comes from cocoa plants taken from Central America to Ghana and Ivory Coast

ISSOUF SANOGO/AFP VIA GETTY IMAGES

Jason Arunn Murugesu is a writer based in Newcastle upon Tyne, UK

New Scientist *recommends*

Bethan Ackerley
Subeditor
London

Last year, I had the pleasure of seeing ***Kyoto*** at the Royal Shakespeare Theatre in Stratford-upon-Avon, UK, a play about the 1997 United Nations Climate Change Conference (or COP3, for short). It was a fantastic production, so I was pleased it has transferred to London's @sohoplace until 3 May.

Stephen Kunken (pictured) stars as Don Pearlman, a lawyer working for the fossil fuels lobby to prevent climate action. Pearlman is the kind of adversary you would dread: a brilliant strategist and libertarian firebrand, the devil in a dark grey suit.

Opposing him is the Argentinian diplomat Raúl Estrada-Oyuela (Jorge Bosch), Pearlman's one-time friend, tasked with forcing the nations into agreement, sort of.

The premise doesn't sound likely to make for great theatre, but the result is tense, informative – and very funny. With last year's COP29 reaching a deal far short of what is needed, clearly there is still much to learn from this story.

MANUEL HARLAN

Learning to read the runes

Here's my prediction: you will love a new exhibition on archaic ways of telling the future. The show may be tiny, but it packs a big punch, says **Simon Ings**

Exhibition

Oracles, Omens and Answers

ST Lee Gallery, Oxford, UK

Until 27 April 2025

IAN WALLMAN

THERE can be few happier disciplines than the history of science: the study of how people did the best with what they had and, generation by generation, accreted better and better models of the way the world works. We used to call this "progress", and it beats me why we can't carry on using the word and just accept that its processes are way more curious, complicated and contradictory than we supposed.

Oracles, Omens and Answers, in the tiny ST Lee Gallery at the back of the Weston Library, part of Oxford's Bodleian Library, isn't about how we got better at prediction, but more how the desire for personal control over tomorrow drives soothsaying mischiefs, from horoscopes to cartomancy (which uses playing cards) and necromancy to Ouija.

The moral is that before we sneer at prognostication methods of the past, we need to take a long, hard look at our world, with its huge investments in predictive AI and futurology departments blooming at elite universities such as Oxford, Stanford in California and Aarhus in Denmark.

The Bodleian's small exhibitions have a history of punching well above their weight. *Thinking 3D: Leonardo to the present* was my favourite, while *Tutankhamun: Excavating the archive*, despite its wee size, proved a major contribution to the centenary celebrations of the discovery of the pharaoh's tomb.

My first thought was that *Oracles, Omens and Answers* had bitten off more than it could chew. Put Cameroonian spider divination next to Joan Quigley's paperback account of her time as astrologer at the White House during Ronald Reagan's tenure as president, and you are spreading your argument about the nature of prediction very thin indeed.

Still, the longer I spent among tarot cards, China's prophesying yarrow stalks, Yemeni sand divination tables and articles

"The exhibition gave me a visceral sense of why astrology has dominated the history of prediction"

in 1980s astrology magazines, the more I found myself dwelling on the big questions. For example, which divination systems presume the world is deterministic, and which are stochastic, making forecasts about likely events on the basis of past data? I was startled to discover that necromancy is stochastic. It is powered by the advice of demons who, doomed to walk Earth since before Adam and Eve were turned out of the Garden, are presumed to know a thing or two about how things might turn out.

Here is another big question. Does the distinction the Roman poet Cicero made, in 44 BC, between divinely inspired predictions and artful forecasts, hold up? The show's co-curator, David Zeitlyn, is an expert on African spider divination and is keen to point out that arachnids moving marked leaves about in a pot is as much a practical randomisation method as a mysterious echo from the "beyond".

And what about those intricate, medieval sortes – texts used for divination – with their cardboard cogs and paper dials? Are they making random-number forecasts easier for non-experts or dazzling rubes with layers of mathematical obfuscation?

I went in thinking that the show was a wild selection of amusing tidbits and walked out wondering about fate and chance, trust and power. Being a *New Scientist* type, I had expected rather more about prediction and big data – MIT's large language model-powered cartomancy booth was a bit gratuitous, and really the show's sole disappointment.

Is fortune telling about the drive for personal control over uncertainty?

Still, the positives far outweighed the niggles and I left much the wiser. In particular, the exhibition gave me a visceral sense of why astrology has dominated the history of prediction. When the night sky is filled with a vast, reliable but (thanks to the motions of the planets) rather complicated clock, why wouldn't you use it? You would be a fool not to assume a deterministic universe and at least try to connect its motions to earthly events.

Yes, I misled you: this isn't, after all, a history of science exhibition. Rather, it is about how we started asking the difficult questions that made rational enquiry possible in the first place. To make "progress", it helps to know where you started from and *Oracles, Omens and Answers* is an ideal beginning. ▮

Simon Ings is a writer based in London

Events

NewScientist

LAST CHANCE TO REGISTER, ONLY ONE WEEK TO GO!

Instant Expert

Inside the subatomic universe

Saturday 18 January 2025 | 10am - 5pm
Congress Centre, London

Join six leading experts to find out everything we know about the subatomic world. Take a deep dive into the building blocks of the universe, from the atom to the standard model, and learn how cutting-edge particle accelerators are uncovering the mysteries of mass, quarks, neutrinos and beyond.

- Learn about the standard model of particle physics and why it's only the beginning
- Uncover the incredible results from particle colliders such as the LHC at CERN
- Discover neutrinos, the strangest particles in the universe
- Find out why matter has mass
- Explore why there is more matter than antimatter in the universe

The expert speakers:

Henrique Araújo
Astro particle physicist, Imperial College London

Harry Cliff
Particle physicist, University of Cambridge

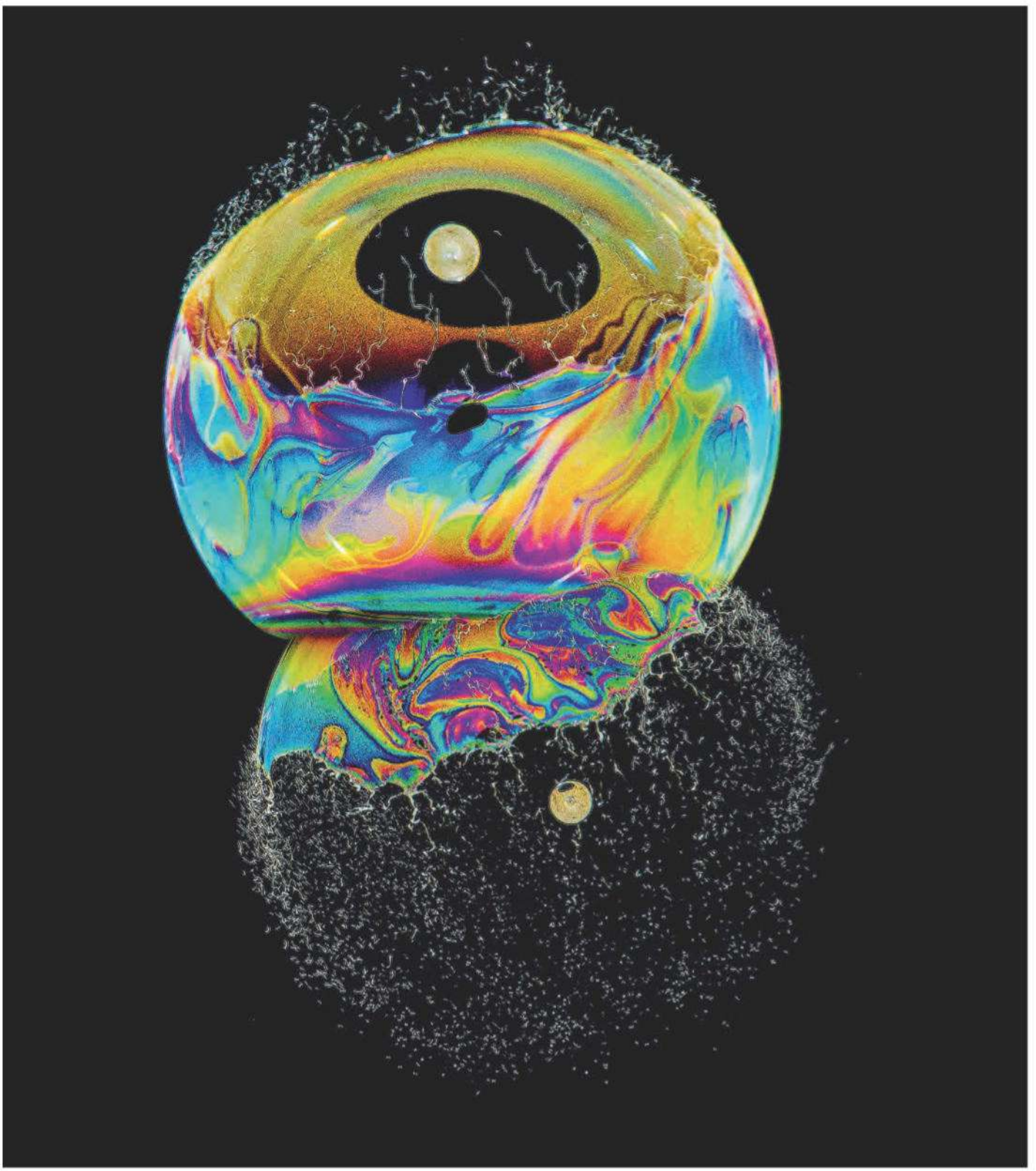
Linda Cremonesi
UKRI Future leader fellow and Reader, Queen Mary University of London

Kate Shaw
Experimental particle physicist, CERN

Tara Shears
Professor of physics, University of Liverpool

Maria Ubiali,
Particle phenomenologist, University of Cambridge

Find out more at
newscientist.com/subatomicuniverse



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Bursting the bubble

A radical new insight into the nature of quantum reality suggests that multiple parallel universes might not exist after all. **Michael Brooks** investigates

EVERY now and then, it is worth pausing for a second and giving thanks to the many, ever so slightly different versions of you that exist in parallel realities. It is these alternative selves that help to keep these universes in balance.

At least, that is what's going on if you happen to subscribe to the many-worlds interpretation of quantum theory. First proposed more than 65 years ago, the idea is that reality is constantly splitting off into parallel paths, due to subtle interactions at the level of quantum particles. Though it may boggle the mind, it also smooths over some devilishly tricky problems in physics and, for that reason, plenty of clear-eyed physicists believe it to be true.

But now this strange idea might be facing a huge challenge, thanks to physicists Sandu Popescu and Daniel Collins at the University of Bristol, UK. They initially set out to solve a 100-year-old puzzle in quantum theory, but ended up undermining the idea of parallel universes. "We've essentially demolished one of the arguments for it," says Collins.

It might sound like a destabilising development, but it may actually prove to be a shot in the arm for quantum theory. Already, Popescu and Collins's work is helping to resolve other long-standing quantum paradoxes and, in the eyes of some theorists, it points to a fresh way of thinking about the cosmos as a singular quantum reality built from the inside out. "This is something deep and new. I think it could become really important," says Nicolas Gisin, who researches the foundations of quantum theory at the University of Geneva in Switzerland.

The story of these outlandish results starts with a basic principle that has run through the bedrock of physics since long before quantum theory was conceived. That principle is called conservation and it applies most famously to energy. It simply says that certain things, including energy, are always conserved. This means they can't be destroyed, only converted into different forms: slam on your car's brakes, say, and the kinetic energy doesn't vanish, it is merely converted into heat and sound energy in the brake discs, pads, wheels and tyres.

In theory, the laws of conservation don't just apply to large objects like cars, but also to all the smaller things governed by quantum rules, including atoms and subatomic particles such as photons and quarks. Quantum theory should be subject to them too. But there has always been a problem.

Think inside the box

To begin unpacking that problem, let us imagine we set up an experiment where an electron is fired towards 10 boxes and might end up in any one. Quantum theory gives the probability of the electron being found in each box. Depending on the electron's trajectory and the relative position of the boxes, that probability might be different for different boxes.

We fire the electron, see where it lands and repeat the process 99 times. The number of times it turns up in each box will match the theory's prediction – quantum theory triumphs.

But let's say we do the experiment just once: now there is no way to predict the outcome because quantum theory has nothing to say about single events, only averages. So what does this really mean?

In the traditional view of it – as put forward by its founding father Niels Bohr – the system is in a "superposition" of all possible states before the measurement, so in our thought experiment, the electron effectively exists in all 10 boxes. This is a huge problem, especially if you take the idea to its logical conclusion, as Erwin Schrödinger did in his famous thought experiment involving a cat in a sealed box, which, through a sequence of events that are subject to quantum laws, is both alive and dead until someone opens the box, "measures" its state, and either the dead or alive version disappears.

That's strange enough, but if we tweak our scenario, an even deeper problem arises. Let's now imagine we are measuring the electron's momentum, rather than its position. Unlike position, momentum is subject to the laws of conservation, meaning it can't just appear from nowhere. But the superposition state of the possible values of momentum before the measurement will be a totally different kind of quantity to the final measured value. Some momentum does seem to appear (or disappear). That is a violation of the law of conservation of momentum. "Since we cannot know what it was at the start, it seems to have jumped," says Collins. "This seemed impossible to avoid."

In other words, quantum theory makes a mockery of conservation laws – and physicists have been wrestling with the implications for a century. Some gloss over this paradox by saying that perhaps things are just different in the quantum world, so it isn't fair to expect the theory to comply with standard conservation laws. "Since quantum mechanics is so counterintuitive and seemingly paradoxical, people have been perhaps far too ready to accept any strange behaviour," says Collins.

Others insist that it does matter, and this is where the many worlds interpretation (MWI) comes in. Not only does it explain what happens to the dead-and-alive cat – one version persists in another universe – it also appears to solve the problems with ›

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DAVID PARKER/SCIENCE PHOTO LIBRARY

Particle physicists use symmetries to find new facets of reality

conservation laws. If you consider all the universes together, then no momentum has been created or destroyed after all.

Collins and Popescu weren't as relaxed as some physicists about the seeming violation of conservation laws. In a thought experiment published last April, part of a body of work produced in recent years, the pair showed that momentum is, in fact, conserved across any single quantum measurement event – and for surprising reasons. "We have taken it much deeper," says Popescu.

They begin with the simple case of a particle moving in a circle and then imagine measuring its angular momentum – another conserved quantity. This gives a definite outcome, yet the particle was in a superposition before, so something has clearly changed. Where could this angular momentum change have come from?

First, they considered the measuring device. "You know it is interacting, so you think surely something passes between the measuring device and the system," says Collins. But their calculations told them this wasn't the case.

Next, they considered the apparatus that puts the moving particle into its superposition, called the preparer. This revealed a quantum version of robbing Peter to pay Paul. If, after the measurement, you add up the angular momentum of the particle and the angular momentum of the preparer, you will find that the total quantity remains the same as it was when the preparer and the particle first interacted. In other words, the preparer is actually part of the superposition and keeps everything precisely in balance.

In real-world experiments, the preparer might be a set of laser photons that knocks a trapped ion into its superposition state before the measurement is taken. Collins and Popescu found that the laser field and the ion would have a "residual entanglement". That is, they are bound together in the superposition, the outcome of which is yet to be decided. And whatever the momentum change of the ion turns out to be, there is always a balancing change in the angular momentum of the laser photons.

This innovation in conservation gives us a completely unprecedented view of quantum processes. We have never before been able to talk meaningfully about the numbers behind a single quantum event. "This is a change in one of the most basic assumptions about the laws of quantum mechanics," says Popescu.

One of the immediate implications is, of course, for the many-worlds interpretation . If conservation laws are obeyed in this universe, that undermines the need to invent others. In which case, the new work resolves the paradox that the MWI has recruited to its cause. "What we show is that, in each individual branch, you have conservation for the individual cases," says Popescu. "So, your argument that many worlds helps, doesn't help." Quantum theorist Renato Renner at the Swiss Federal Institute of Technology in Zurich agrees. "It offers the possibility that even without many worlds, we can have a consistent view," he says. "It's one reason less to believe in many worlds."

That said, Lev Vaidman, a staunch advocate of the MWI, is unperturbed by Collins and Popescu's result. A theorist at Tel Aviv University in Israel, he argues that the role of conservation laws is overblown. "I was not particularly concerned about the so-called paradox," he says. In Vaidman's view, conservation laws would hold within each world described by the MWI anyway, which is in line with Collins and Popescu's finding.

For his part, Collins regards this all as a cautionary tale to avoid ideological stances when it comes to interpretations in quantum mechanics: assuming the MWI is valid makes you stop thinking about the problem, he says. "You would have never discovered the role of a preparer or any of this. You would have just thought that everything is fine."

Now, it seems these new insights into quantum conservation laws could open avenues for grasping the core of quantum mechanics. For example, it points to the importance of an idea called reference frames, when making quantum measurements.

You can think of reference frames as a kind of point of view from which the physics is observed. Collins and Popescu say that the reference frame for a quantum measurement is set by the attributes of the preparer apparatus – and that knowledge of this frame of reference is an essential part of establishing conservation in individual quantum measurements.

This is potentially profound. That's because reference frames are an essential part of yet another idea that forms part of the bedrock on which physics is built: symmetry. In physics, this concept of symmetry means that you can transform a system by, say, flipping it or rotating it, and it will remain the same – and there is a deep connection between these symmetries, conservation laws and new discoveries in physics. "All of physics is symmetry, and from symmetry you get conservation laws – that's why conservation laws are so useful," says Collins.

Preference for symmetry

The mathematician Emmy Noether was the first to show, in 1918, that conservation laws are a result of the universe's preference for symmetry in all of its processes. Since then, whenever physicists found new symmetries, or instances where they are violated, that is where they found something worth investigating. For example, the existence of many particles in the standard model of particle physics – such as quarks and the Higgs boson – were predicted in this way. Experimentalists then built billion-dollar machines to go and find them.

With the new work, reference frames, symmetries and conservation laws are now tied together in the quantum world, in the same way they have been in classical physics. "It's not that they have just solved a complicated equation that no one else has been able to solve before: they really have an insight into the physics," says Gisin.

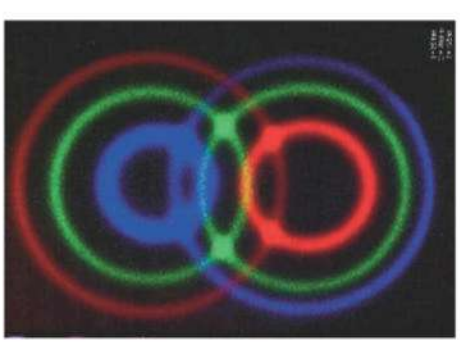
Already Renner thinks that this connection could help to settle yet another persistent quantum paradox. In the 1960s, Eugene Wigner devised a thought experiment known as Wigner's friend. In it, his friend is measuring a quantum system akin to the cat-in-a-box one, in a lab. Meanwhile, Wigner stands outside the lab behind a closed door. The paradox occurs when his friend opens the box to, say, find that the cat is still alive. But from Wigner's point of view, the cat is still in a superposition of being alive and dead, while also being entangled

"I'm left in an uncomfortable superposition of agreeing and disagreeing with the finding"

with Wigner's friend. These realities are mismatched, yet according to quantum mechanics, both are correct.

However, a more precise understanding of reference frames could help here, says Renner. The paradox assumes that the friend exists in a pure quantum state that is distinct from Wigner. But Collins and Popescu's result shows that this is impossible, as the friend must also be entangled with the preparer – which, in this case, is Wigner himself. So, the effects of the preparer, which are usually small and can be ignored, must now be taken into account. "Maybe these paradoxes can be resolved if you are more careful in the modelling of Wigner's friend," says Renner.

All this is causing Renner and others to lean towards a picture of reality that is starkly different to the MWI. The idea that measurements are relative to observers and their reference frames is baked into two alternative interpretations of quantum mechanics. First, relational quantum mechanics says that objects don't exist independently of each other and reality only arises through relational connections.



PAUL KWIAT AND MICHAEL RECK/IQOQI VIENNA/OEAW

Quantum entanglement may help to explain how energy isn't created or destroyed

Meanwhile, quantum Bayesianism, or QBism, regards quantum mechanics as a tool observers use to make predictions about the outcomes of measurements. In QBism, reality is defined through the relations between these observers and the measurements they make. Instead of myriad alternative realities continually branching away from our own, these relational interpretations build a singular universe up from within by stitching together many subjective perspectives.

There is still plenty to be done, though, to shore up Collins and Popescu's result. So far, they have only theoretically demonstrated conservation of angular momentum and then assumed it applies to conservation laws more broadly. But Jonte Hance at Newcastle University, UK, says that it isn't clear the result would hold when applied to conservation laws involving energy and time – especially as the concept of time in quantum mechanics isn't well understood.

Valia Allori, a philosopher of physics at the University of Bergamo, Italy, is also cautious about the result. There are subtle but problematic "leaps" in the argument, she says. "The leaps are in the nature of interaction between the [particle] and the measurement device, or the [particle] and the preparer."

Experimentalists are now thinking about how they could observe each of the conservation laws in practice. "These individual quantum conservation laws could be seen as imposing restrictions on the kinds of quantum states that can be prepared, motivating experiments to try to generate and measure them," says Aephraim Steinberg at the University of Toronto.

When he first saw the work, Steinberg's intuition was that it couldn't be right. But he has since studied the paper a fair bit and has "started to find it surprisingly convincing", he says. "I'm left in an uncomfortable superposition of agreeing and disagreeing with them."

Whatever pans out, Popescu hopes that his research with Collins challenges the long-held belief that we will never progress in making sense of quantum theory. "It's a common thing for people to say that nobody understands quantum mechanics," says Popescu. "Well, we're trying to build that understanding." ▮

ANDREW PERRIS

Michael Brooks is a consultant for *New Scientist*

Cold comfort

Some penguins are proving to be surprisingly adaptable, but it may not be enough to save them from climate change, says **Colin Barras**

A ROVER quietly surveys the forbidding icy landscape. Suddenly, it whirrs into life: it has spotted an emperor penguin. With its antenna set to scan, the 90-centimetre-long robot trundles towards the bird, searching for a signal from an RFID chip beneath the penguin's skin – recording crucial information that may help us finally understand this enigmatic species.

The emperor penguin is instantly familiar as the star of countless nature documentaries and the 2005 movie *March of the Penguins*. This media exposure might give the impression that we have a solid understanding of its biology. We don't. Almost all of that footage was collected from just two breeding colonies on opposite sides of Antarctica, constituting perhaps 10 per cent of the emperor penguin population. For decades, the hundreds of thousands of emperors living elsewhere along the continent's coast were virtually unstudied.

That situation is now changing. Over the past 15 years, researchers have uncovered more about these birds using new technologies, including satellites that can spot colonies from space and AI-equipped robots to scan them on the ground. "I hope we're starting to go into a golden age of research," says Daniel Zitterbart at Woods Hole Oceanographic Institution, Massachusetts.

Already, the work has revealed subtle differences in the genetics and behaviour of the penguins at different points around the Antarctic coast, and shown that they are surprisingly adaptable to changing conditions. But these discoveries have been made amid rapid warming in the region, which led the US Fish and Wildlife Service to declare emperors a threatened species in 2022. Can new insights help us protect one of the world's most iconic birds?

At 1.2 metres tall, the emperor is the largest living penguin species. Its size may be an adaptation for life in Antarctica – bigger bodies conserve heat better than smaller ones – but it has knock-on effects for behaviour. For instance, smaller penguins will readily hop or clamber over rough terrain, but emperors struggle to do so. They can only march, slowly, across flat ground. This explains why emperors

STEFAN CHRISTMANN/NATUREPL.COM

The emperor penguin breeding season is fraught with danger

rarely stray onto land. When they exit the water, they typically do so onto "fast ice" – relatively flat sea ice that is stuck fast to the coast, the side of a glacier or another object.

It is on this fast ice that most emperor penguins breed – and again, their size is a factor in their breeding behaviour. "Smaller penguins can complete their breeding cycle within the short Antarctic summer," says Peter Fretwell at the British Antarctic Survey (BAS) in Cambridge, UK. "But when you're raising a larger chick, you just haven't got the time."

Instead, the female emperor penguin lays a single egg in May or June, just before the peak of the Antarctic winter. She passes it to the male, who tends to the egg on the fast ice as temperatures plunge below -50°C (-58°F). The chick hatches towards the end of winter and spends its first months on the ice. It fledges around mid-December – in the Antarctic summer – at which point it has sufficiently waterproof feathers to survive the cold waters.

Signs from above

This unique practice means emperors have to choose their breeding sites carefully. On the one hand, they must avoid places where the fast ice grows and extends too far from the colony during the winter, because then it takes the adults too many days to trudge to the sea for food and the hungry chicks starve. On the other hand, they must also avoid places where the fast ice recedes too rapidly in the Antarctic summer, because the colony risks falling into the sea before the chicks have fledged, meaning most will drown. "It's a really fine balance," says Fretwell.

The challenges of conducting research on and around the hostile Antarctic meant that it was once extremely difficult to know how often penguins get that balance right. Then, 15 years ago, Fretwell and his BAS colleague Philip Trathan made a pivotal discovery. They realised that known breeding colonies were visible on satellite images, due in part to the way penguin droppings stain the ice.

By analysing satellite images, Fretwell and Trathan identified 28 known colonies – and an additional 10 that were previously unknown. Since then, improvements in ›

“More people have travelled in space than have handled emperor penguins”

DANIEL P. ZITTERBART

satellite imaging resolution have helped identify even more. As recently as last year, Fretwell spotted four previously unknown colonies, bringing the total number to 66. “It’s incredible what we can do now compared to just a few decades ago,” he says. There are now plans to use synthetic-aperture radar satellites, which create a high-resolution 3D map of the ground and will allow researchers to track the penguins even during the peak of winter, when the colonies experience several weeks of total darkness, says Fretwell.

The satellite images obtained so far have underscored the emperors’ ability to survive against the odds. For example, last year satellites spotted a huge glacier coming to a halt next to a breeding colony at Halley Bay in east Antarctica, apparently trapping the birds on the fast ice there. Somehow, the penguins survived. Perhaps the adults found a way to dive beneath the iceberg to reach the open waters of the Weddell Sea where they forage for food for their chicks.

But satellite observations get you only so far. Even with modern high-resolution images, it is challenging to get accurate penguin population counts. All you can really do is measure the ground area the colony covers and take an educated guess as to how many penguins are packed inside that space. “It’s incredibly uncertain,” says Zitterbart.

On-the-ground observations can boost accuracy, and here researchers rely on the fact that two breeding colonies – at Atka Bay and Pointe Géologie – lie within a few kilometres of scientific stations, making them relatively accessible for researchers. Zitterbart and his colleagues analysed these colonies a few years ago and discovered that they could use temperature and wind-speed data to predict whether the penguins would be scattered across the landscape or tightly packed in a dense huddle. In a study published last year, they argued that this greater understanding of penguin behaviour should allow for more accurate population estimates using satellite images. Put simply, researchers could use data from weather stations to estimate penguin density at the time a given satellite image of a colony was captured.

However, such research assumes that all 66 breeding colonies are fundamentally similar to those at Atka Bay and Pointe Géologie. It is becoming increasingly clear that this may not be the case. In 2017, Jane Younger, who is now at the University of Tasmania, Australia, and her colleagues collected DNA samples from 110 emperor penguins at eight colonies around Antarctica and found subtle signs that the birds fall into four subpopulations that rarely mix. In 2023, another research team led by Sara Labrousse at Sorbonne University in Paris used satellite images to suggest that each of these subpopulations has developed distinct breeding preferences. For instance, colonies in east Antarctica are found where fast ice remains stable deep into the Antarctic summer, but, surprisingly, those in the Ross Sea tend to occur where the fast ice melts early in the summer. Labrousse and her colleagues concluded that the discovery “radically changes”our understanding of the emperor penguin habitat by showing that populations are flexible enough to make use of the habitats available to them.

Signs of this behavioural flexibility had been observed in the past. Some emperors breed on top of icebergs rather than on fast ice, for example – and a few colonies forego ice altogether and breed on land. This is the case for a breeding colony near Taylor glacier, where the bedrock is flat enough for the heavy

The ECHO robot pictured above (and below, with researcher Daniel Zitterbart) can identify and track the lives of individual penguins

DANIEL P. ZITTERBART

penguins to navigate. "The penguins here are, in a way, lucky," says Barbara Wienecke at the Australian Antarctic Division in Tasmania: they can breed successfully regardless of the fast ice conditions. They may, however, find the rocks uncomfortably hot in summer.

Such adaptability makes sense, says Wienecke. "The Antarctic environment is fierce and greatly dynamic. If you want to survive, you have to be flexible."

In recent decades, that environment has become far more dynamic as the global climate has warmed. For instance, in 2022, 13 colonies probably lost chicks because the fast ice began to break up before the youngsters were fully fledged. But there is some evidence that emperor penguins can respond to these problems, at least in the short term.

Mass migration

The Halley Bay colony provides perhaps the best example of this. Not so long ago, this was the second-largest breeding group anywhere in Antarctica, with several tens of thousands of birds. Then a lack of stable fast ice led to near-total breeding failure for three years, beginning in 2016. The colony collapsed, with just a few hundred adults remaining today. But when Fretwell and Trathan used satellite data to document this collapse in 2019, they found it coincided with the dramatic expansion of another breeding colony 55 kilometres to the south where conditions were more favourable. This more southerly location, the Dawson-Lambton colony, had comprised just a few thousand birds in 2016. It now contains tens of thousands.

It seems that, in the space of just a few years, thousands of emperor penguins abandoned the Halley Bay colony and moved to Dawson-Lambton – an astonishingly fast behavioural change. "Smaller penguins don't really do that," says Fretwell. Species including the 75-centimetre-tall chinstrap penguin, which lives in the South Pacific, seem reluctant to abandon historical breeding grounds even if conditions deteriorate, he says.

Stéphanie Jenouvrier, also at Woods Hole Oceanographic Institution, and her colleagues have begun to incorporate this capacity to migrate into models that predict future trends in the emperor penguin population. The latest, yet-to-be-published versions suggest that under a high-emissions scenario, migration could make a significant difference to the penguin population of 2100. "It may result in up to a 7 per cent larger global population compared to models without dispersal," says Jenouvrier.

A 7 per cent improvement is undoubtedly significant, but it may be cold comfort given predictions that many breeding colonies may drop to less than half their current populations by the end of the century. Such models make clear that emperor penguins are in serious trouble despite their astonishing flexibility. To determine what more can be done to help the species, researchers have to get even closer to the birds.

Doing so isn't easy. Even in the Antarctic summer, the weather can hamper research efforts. "I'm actually there right now," says Zitterbart, who often spends the southern polar summer months at a research base, Neumayer Station III, that lies just 8 kilometres from the colony at Atka Bay. "I walked to the colony today, but it was very stormy and we didn't see a single penguin."

This may explain why so few researchers have managed to catch and handle emperor penguins. "Probably more people have travelled into space than have handled emperor penguins," says Zitterbart.

Catching and tagging the birds can reveal invaluable information for their conservation. Most notably, Jenouvrier, Labrousse and their colleagues discovered that newly fledged emperor penguins swim much further north, away from the Antarctic coast, than we had thought – and far beyond waters that are protected to at least some degree from commercial activities. That has led Zitterbart and colleagues to argue that the whole Southern Ocean should be given protected status, although Wienecke points out that it will be hugely challenging to reach international agreement on such a move.

The ultimate goal would be to track individual emperor penguins over their 20-year life. This has been hard to achieve in the past, since they are essentially indistinguishable from each other to the human eye. It is for this reason that Zitterbart and his colleagues have begun chipping birds at the Atka Bay colony with RFID tags – similar to those used to chip pets – which will allow them to track the birds' progress in the long term. By combining this with data obtained from blood samples, they may be able to identify potential genetic markers associated with the greatest breeding success, which might hint at additional heritable components to emperor penguin adaptability. This could, in turn, improve future predications of population change.

One challenge is that the RFID tags can only be read if the birds pass within a metre or so of a scanner. The solution is a four-wheeled autonomous robot named ECHO that trundles tirelessly around the colony, carrying the scanner to each penguin in turn. The robot is equipped with a depth camera and lidar to build up a 3D picture of the terrain and avoid obstacles. It uses artificial intelligence to recognise penguins and approach them, moving slowly to avoid stressing the birds. Eventually, it will be able to return to solar-powered charging stations on the ice to top up its batteries, making it almost fully independent. Zitterbart and his colleagues have been using the robot for a few years, and although they have yet to discuss it in a formal study, Zitterbart says initial testing shows that it doesn't disturb the penguins.

STEFAN CHRISTMANN/NATUREPL.COM

Male penguins incubate eggs for up to 75 days

The hope is that similar autonomous technology could be deployed at other colonies around Antarctica to get a sense of how the emperor penguin is faring across its entire range. That should also give us information on the health of the Southern Ocean as a whole. "Studying emperor penguins is, of course, important for the future of the species," says Zitterbart. "But it is also important for what it reveals about this big and inaccessible ecosystem."

Whatever the robot reveals about the penguins' breeding habits, most researchers agree that the long-term future of the species depends on how quickly we can move to a low-carbon economy. "I think these remarkable birds have been doing their utmost for a while to adapt," says Wienecke. But, as Fretwell puts it, their survival will be decided not by their behavioural flexibility, but by ours. ▮

Colin Barras is a freelance science writer based in Ann Arbor, Michigan

"Music gives your body and brain a chance to reset"

We are finally starting to understand why music has the power to heal us, as neuroscientist **Daniel Levitin** tells Linda Rodriguez-McRobbie

MOST of us already know that music can have a profound effect on mind and body. Consider the feeling of empowerment when you slip on some headphones and go for a run, the rush of nostalgia you get from hearing your favourite song from your childhood or the joy of singalongs in the car – music moves us, literally and figuratively. It can make us happy when we are sad, sad when we are happy, as well as make us dance, laugh and relax.

But what if it could do more than that – what if music had the power to actually heal us? In his new book *I Heard There Was a Secret Chord: Music as medicine*, neuroscientist Daniel Levitin explains why he believes it can.

The idea that music is medicine isn't new – there is evidence that shamans and healers in cultures across the world have used music, especially drumming, to treat people for thousands of years.

Only in recent decades, however, has science offered a rational basis for music as a mechanism for healing, demonstrating that it has a direct and measurable impact on our nervous system.

Advances in neuroimaging coupled with more rigorous experimentation drawing on music theory, cognitive psychology and physiology suggest that music can be useful in aiding everything from Parkinson's disease to Alzheimer's and depression.

Levitin spoke to *New Scientist* about these health benefits, and how music might be added to our medical toolkit.

Linda Rodriguez-McRobbie: It seems intuitive that music can affect the body, but what has improved our recent understanding of its influence on our health?
Daniel Levitin: Historically, we have had little good evidence for music as medicine. We had a lot of stories. Now we have a lot more rigorous studies looking at the neurological processes underlying our response to music, looking at the overlap between music and non-musical activity in the brain, and clinical models testing the therapeutic effects of music.

We have also come to understand the importance of movement to cognition – we call that "embodied cognition". It's the idea that cognition is fundamentally shaped by the body's interaction with the physical world, rather than being solely a product of abstract mental processes.

So listening to music is a more full-bodied experience than just what happens in your ears?
That's exactly right. I did an event with Stewart Copeland from The Police, and he articulated it as "music is the only art form that makes you want to twitch and wiggle your body". Few people are standing in the Louvre looking at the *Mona Lisa* and wanting to dance to it. But music triggers activity between our ears and our brain's motor system. ›

NATALIE FOSS

Meaning we can't help but move to music?
One thing I've seen in my own neuroimaging studies is that even when people in a scanner who are listening to music are explicitly instructed not to move, the parts of their brains that would be planning and coordinating movement are still active. We have mapped direct connections between the music perception areas of the brain and the motor planning and movement parts of the brain. It's not merely the rhythm of music that drives this, because metronomes don't have the same powerful effect on movement; it is something about the totality, the gestalt of music that causes this.

What do we know about how different kinds of music impact us?
At a really rudimentary level, music with a deep rhythm like James Brown – as opposed to, say, [18th-century composer] Domenico Scarlatti – is going to make you want to move. Listening to different styles of music elicits different strengths of activity in the auditory-movement circuits. For instance, one study showed that reggae evoked the highest activity in this area compared with folk, electronic and classical music.

But our tastes are very subjective. How it affects you depends on what the music means to you, whether or not you like it. So, when we talk about medicinal effects of music, it's not that Joseph Haydn is going to cure the common cold, Joni Mitchell is going to cure depression and [swing-era bandleader] Cab Calloway is going to cure Alzheimer's. It's got to be what it is that you like, because your emotional circuits seem to be involved in music's health effects.

Can you tell me more about these effects and the mechanism behind them?
There's not a single mechanism. If you have a bacterial infection, you take an antibiotic, but if you have arthritis, the antibiotic won't work. The mechanisms of action of particular drugs need to be directed at particular ailments. So, to expand the analogy, not all music makes you want to move and not all movement is curative or "healing".

But when music gets you dancing, it's aerobic and boosts the mood-stabilising hormone serotonin. Playing an instrument can help hand-eye coordination, which is neuroprotective because it encourages growth of new nerve pathways.

"Music can help recontextualise experiences"

Joni Mitchell's music isn't going to heal everyone – but it might help some

PICTORIAL PRESS LTD/ALAMY

So could music help with conditions that affect the brain, like Parkinson's?
When it comes to Parkinson's or other movement disorders, such as motor neuron disease, where there is progressive degeneration of nerve cells in the brain and spinal cord, music helps us synchronise our movements. It can also help us maintain a steady gait, which people with Parkinson's can otherwise find difficult to do.

We think this is because music with a strong rhythm helps populations of neurons fire in synchrony. It's not just the rhythm of the music that is responsible for this. We speculate that music is more effective at synchronising neuronal activity than a metronome because it is engaging and emotional and also has a social aspect to it. Numerous studies have shown how different features of music contribute to this synchronisation of brain responses, each is like a strand of a rope that works together to promote synchronisation.

I've heard that music can also help people who have lost the ability to speak after a stroke
Yes, you can use music to cure aphasia, loss of speech – that's a different mechanism entirely. Music circuits can be preserved in the face of damage to the speech centres, and so you can learn to sing what you want to say, and, eventually, the brain rewires itself so that you can say it without singing.

ZELJKOSANTRAC/GETTY IMAGES

Playing instruments can help promote new connections between brain cells

FATCAMERA/GETTY IMAGES

You mention in your book that music can even help people with Alzheimer's. How?
With Alzheimer's, it's something completely different again. Music seems to help you access old memories that you have lost touch with. Everything that has happened to you, every experience, is encoded in memory somewhere. Memories also encode the context surrounding an event. If there's a particular song that you heard and it was associated with a particular span of time – like that summer you turned 13 years old – the music becomes associated with all the other events of that time: your friends, the movies you saw, the books you read and so on.

Alzheimer's destroys areas of the hippocampus, which is where we believe memories are indexed, if not stored. We believe that music acts as a retrieval cue, which helps you access memories that are preserved but difficult to locate.

Does music also help with conditions like depression?
Yes, it can have a significant effect on reducing symptoms of depression. Music helps you recontextualise your experiences. As an example, we know that when people "pull out" a memory, the mood they are in can alter the original memory such that when it gets "put back" into storage, it can take on a different valence. In this way, calm music can help to make a traumatic memory less powerful, and uplifting music can make a memory less fearful.

You have written that music also engages the brain's default mode network, allowing us to get into a trance-like state. How does that benefit us?
It's easier to understand it when you contrast that state with our regular mode of thinking, where we use "the executive attention network". This is where you are trying to focus on something and consciously guiding your thoughts. The default mode network is the opposite – you're not in control of your thoughts, it's like a daydream state. These two networks function like a seesaw, a teeter-totter, because one is active when the other isn't.

It takes an act of will, of deliberate intervention, for us to focus on something. That focusing comes with a biological, metabolic cost in the form of spent glucose, the brain's fuel. The default mode helps to replenish that glucose, in a similar way that sleep does.

We also think that some kind of physical healing happens while in the default mode. The brain typically repairs damaged cells while you are asleep. We think this is partly because acetylcholine and other chemicals, some of which are involved in the immune system, set up a kind of programme for cellular housekeeping. We don't know for sure, but it seems as though this kind of housekeeping can happen when you're in the default mode, too.

Music engages your default mode network and therefore gives your body and brain a chance to reset.

We know that people have emotional connections to the music that is right for them, but can, say, listening to calming sounds like water make you feel better?
Sounds of nature that aren't threatening – like a river flowing rather than a hurricane – those tend to be calming. Music with a slow tempo and stepwise motion also tends to be calming. Most people wouldn't find distorted electric guitar music calming, but there are some people that will, there's always going to be individual differences. Why some songs are calming and others are not is an area of active research that we are working on.

That said, none of the playlists that are on the commercial services for relaxing music are chosen by scientists. They're just a bunch of people saying this relaxes me, so there's no science behind them. ▮

Linda Rodriguez-McRobbie is a features editor at *New Scientist*

The back pages

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Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

Debunking gardening myths

Slippery subject

Social media is rife with claims you can use banana peels to fertilise your plants. **James Wong** unpeels the science behind the trend

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

BACK in the 1990s, the kids in my high school were convinced that banana peels contained a mysterious psychoactive substance that could apparently induce vivid hallucinations when smoked. I suppose it's the tragic fate of the elder millennial that, 30 years later, the same people are now positive that the real excitement banana peels have to offer is in caring for their houseplants. With hundreds of social media posts touting the apparently transformative effect banana peels can have on plant growth, I set out to learn if there was any evidence for this claim.

Some proponents argue that the peel should just be laid to decompose on the top of your plant pots. (Sounds a delightful thing to have in your living room.) Others say it should be sealed in jars of water for a few days, before pouring the resultant "tea" on your plants. A third school of thought involves baking the peel in a low oven until it turns black, and grinding the charred skins into a powder to mix into soil.

The bottom line is that fertilisers boost growth by supplying the essential elements plants need, in particular nitrogen, phosphorus and potassium. So, how much do bananas peels contain? There have been a range of studies that have investigated this question, and although they often looked at blends of banana peels with other ingredients like manure and bone meal, they all returned similar results. The peels have much lower levels of the three major nutrients than standard fertiliser. While they do contain a decent amount of potassium (essential for flower and fruit formation), their levels of nitrogen (essential for leaves) are minuscule.

SHUTTERSTOCK/THAMKC

As most houseplants are grown for their leaves, not for their fruit, this means banana peels wouldn't be a great choice, especially as they are weaker in all essential nutrients than standard commercial plant food.

However, they do have one big advantage: they are free, not to mention environmentally friendly. So, could the cost-benefit make it worth it? If you incinerated the peels into ash, then perhaps. (Everyone has the kit at home to do that, right?) But simply adding the skins to water for a few days will only extract a tiny fraction of these minerals. Similarly, even if you were to brave the idea of leaving them to rot in the pots around your apartment, the sterilised potting mix used for houseplants is unlikely to have the microbial life to unlock the minerals in the peel into a form your plants can use.

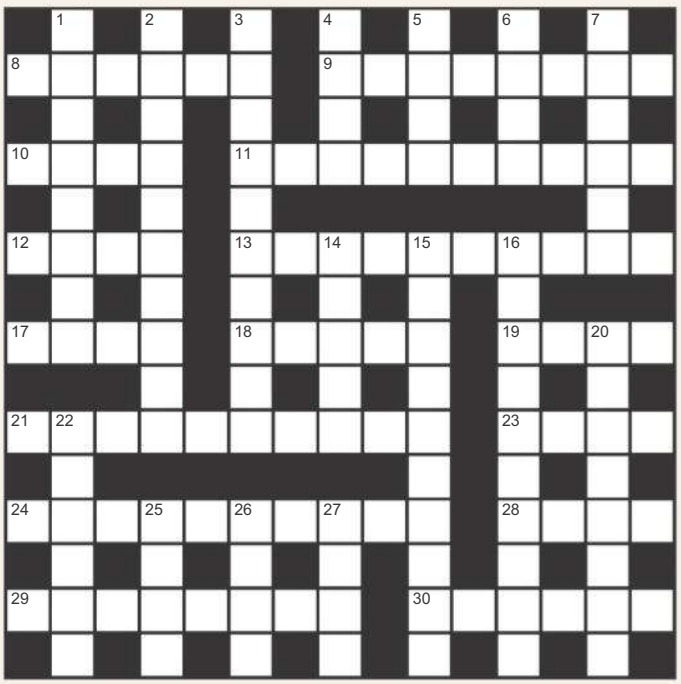
So, theoretically, yes, banana peels can be used to make fertiliser industrially, when combined with ingredients richer in the minerals they lack and processed in ways you can't easily replicate at home. But the reality is they make as good a houseplant fertiliser as they do a smoking material. ▮

Debunking gardening myths appears monthly

Next week
The science of exercise

These articles are posted each week at newscientist.com/maker

Quick crossword #174 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

8 Asterism also known as the Big Dipper (6)
9 One of the most widespread of the curlew wading birds (8)
10 Volcanic rock (4)
11 Scientist's workplace, possibly (10)
12 Zn (4)
13 Blowfly *Calliphora vomitoria* (10)
17 Dwarf buffalo (4)
18 4:3, say (5)
19 Radix (4)
21 Zigzagging sloped track (10)
23 ∴ (4)
24 Ancient fish rediscovered in 1938 (10)
28 10s (4)
29 Notorious opioid (8)
30 Of an atom, to gain or lose an electron (6)

DOWN

1 Misleading sensory phenomenon (8)
2 Component of detergents and emulsifiers (10)
3 Labour (10)
4 (Take a) sample (4)
5 Row (4)
6 Be next to (4)
7 Gasoline (6)
14 Extremely (prefix) (5)
15 Distributed ledger (10)
16 Solvent distilled from resin (10)
20 Living thing (8)
22 Bass speaker (6)
25 Overdue (4)
26 Tapered 3D shape (4)
27 A zero value (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #284
set by Corryn Wetzel

1 What is the most famous fossil of an Archaeopteryx called?

2 What was the name of the first search engine on the internet, created in 1990?

3 What is the name of the highest mountain on Mars?

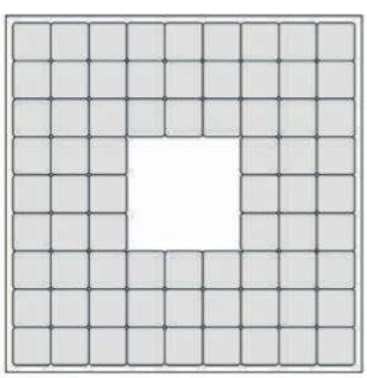
4 What is the process by which a solid turns directly into a gas?

5 How many hearts does an octopus have?

Answers on page 47

BrainTwister
set by Alison Kiddle
#55 Squares in squares

I have 72 mosaic tiles, which I have formed into a square picture frame. The frame measures 9 by 9, and it can display a picture of size 3 by 3.



Can you use the same tiles to create a square picture frame of a different size that holds a bigger photo?

For square frames like this more generally, with a square photo in the exact centre, how many tiles might you need? What properties do these numbers share?

Given a number of tiles, can you determine which possible frames can be made?

Solution next week

On the level

If Earth was flat, how would gravity manifest?

Mel Earp
Macclesfield, Cheshire, UK
That is a brilliantly simple question, yet so revealing. To answer this, we need to put to one side how an Earth with a flat side would form. With Newtonian gravity, this would be quite difficult, as any planet or celestial body large enough would tend towards being spherical.

If we ignore this but still assume there is Newtonian gravity, the key driver would be where the centre of mass of this Earth was. The gravitational force on the flat surface would act towards this point.

We can immediately see two effects. Firstly, the distance between a point on the surface and the centre of mass varies and therefore so would the strength of gravity across such a flat Earth. Secondly, the angle at which gravity acts varies too: the directions you feel to be up and down wouldn't stay the same or be perpendicular to the ground except at the point on the surface directly "above" the centre of mass: the gravitational epicentre.

"The edge dwellers of a hemispherical Earth might develop specialised means of locomotion to cope with the gravity"

As an example, suppose this Earth were a hemisphere with its inhabitants living on the flat surface. Also assume it was of uniform density and, being "half an Earth", half the mass of our planet. (You would have to consult the local geologists as to why this is the case.)

In this scenario, the centre of mass is ⅜ of the radius down from the centre of the inhabited disc. This results in the gravity at the edge being about ⅛ of that at the centre, just because of the increased distance from the centre of mass. This is quite some difference. Even more dramatic is the angle: at the edge, you would feel gravity at an angle of just less than 70 degrees from the vertical. You would almost be lying down with respect to the ground to stay "upright".

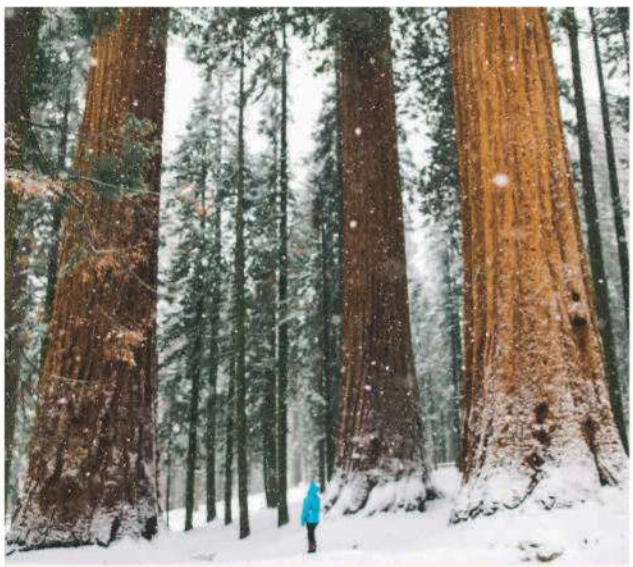
It would be very confusing indeed to us, as we are used to the spherical Earth. Your eyes would tell you it is flat, but your inner ear would say you are on a very steep hillside.

At the centre of the disc, the strength of gravity would be just over 3.5 times the strength of our gravity, which is almost constant across the globe. That is despite the mass of this Earth being half that of our planet. This is because you would be so much closer to the centre of mass. At the edge, it would be less than half of our Earth's gravitational force.

Evolution on a hemispherical Earth would be interesting too. Edge dwellers might develop specialised means of locomotion to cope with the angle of action of gravity. They might well have the characteristics of mountain goats.

Since the strength of gravity would dramatically increase as you moved from the edge to the centre, these creatures probably wouldn't be able to survive moving towards it.

Circular bands of adaptations might well develop, with much stronger and more powerful creatures in the central ocean and less powerful, but nimble creatures at the edge.



PETER AMEND/CONNECT IMAGES/ALAMY

This week's new questions

Forest life **Why don't trees rot in the ground, while wooden structures do if they aren't built properly?** ***Caroline Deforche****, Lichtervelde, Belgium*

Nodding off **If humans needed to hibernate, how would civilisation have developed?** ***William Strudwick****, Grayshott, Hampshire, UK*

Why don't trees rot in the ground, given other wooden structures often do?

Mike Follows
Sutton Coldfield, West Midlands, UK
We are pulled towards the centre of gravity of whatever object we stand on. For a spherical Earth, which is spherically symmetric, this is downwards towards the centre of the planet.

If we were to move across the surface of a disc-shaped Earth from its centre towards its edge, the direction of gravity would gradually swing away from the vertical, eventually becoming nearly horizontal by the time we reached the edge.

The thinner the disc, the closer to horizontal this force vector will point. In this scenario, buildings would need to be constructed as though on an increasingly steep incline, so that the floors would always remain at a right angle to what we perceived as "down".

Rather than falling off the edge, we would be able to stand on it comfortably, with the centre of gravity directly beneath us. The truly unsettling situation would be falling back along the surface towards the centre of the disc.

Some believe that a flat Earth is constantly accelerating upwards, as if in freefall, which gives us the perception of downward acceleration and weight.

To create a flat Earth that mimics the sensation of gravity pulling in the same direction everywhere, the distribution of mass would need to resemble something like an hourglass shape in cross-section or two oppositely facing cones joined at their apexes.

Of course, it could be made to have a uniform thickness by adjusting the density distribution to mimic the required mass distribution, but this would be extremely difficult to achieve in practice.

To cosmic rays travelling close to the speed of light,

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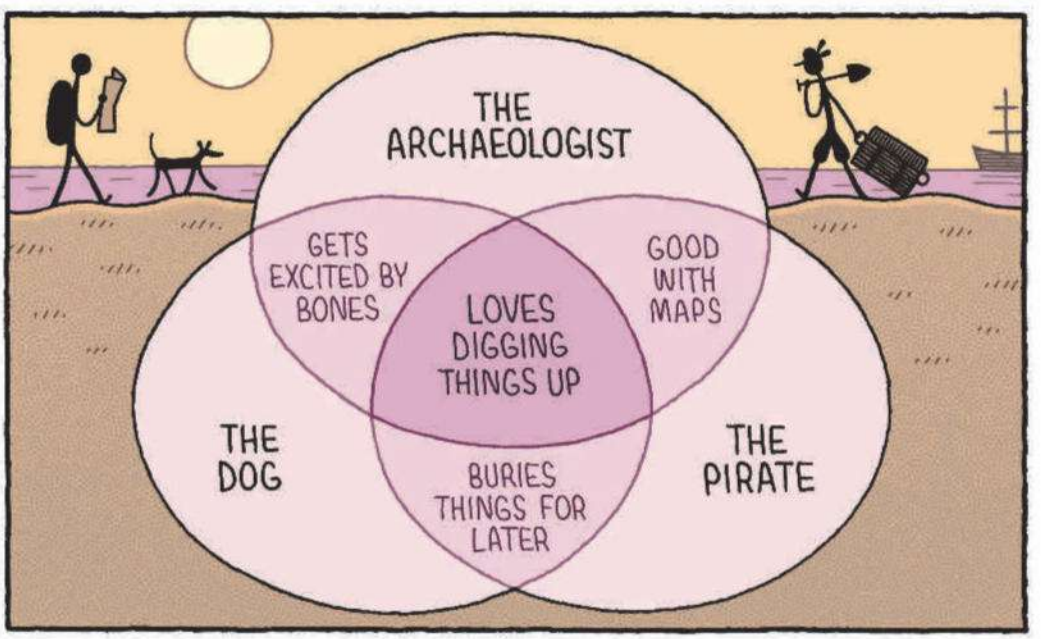
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Tom Gauld
for New Scientist



Earth already appears length-contracted and therefore flat.

Red shift

Why do so many Scottish animals have red fur or hair, such as red squirrels, red deer, Highland cows and red-headed humans?

Anthony Woodward
Portland, Oregon, US
In humans, the recessive gene MC1R plays a part in producing red hair. Recessive genes are more likely to accumulate in isolated communities. The Highlands and islands of Scotland offer a few impediments to travel, but not many. About 13 per cent of the Scottish population have red hair, compared with about 1 to 2 per cent in the global population.

The genes for red hair probably originated in the grasslands of central Asia, spread to western and central Europe where the Celts originated, then spread with the Celts further afield.

More Celts survived in Ireland and Scotland because these countries are further from the sites of Roman and Anglo-Saxon invasions and were more difficult to conquer than England.

"About 13 per cent of the Scottish population have red hair, compared with about 1 to 2 per cent in the global population"

The current geographic range of the red squirrel extends beyond Scotland into northern England. Fur colour has several purposes: camouflage, a warning to predators, identification for mates and thermoregulation. The squirrel's red fur camouflages it against the bark of the pine trees in which it lives. Darker fur absorbs more solar energy, with black fur doing so more efficiently than red.

The red deer of Scotland are a subspecies of the European red deer. They form the largest remnant of a group of red deer that came to the British Isles during the last glacial maximum. Their range includes northern England as well as Scotland. Red deer occur in much of Europe.

Highland cows have lived in Scotland at least since AD 600, but back then they were black! As recently as 1880, the majority were still black, according to the early herd books. It was the Victorians who selectively bred the cattle for their now-famous reddish coat.

So it seems that red fur isn't special to Scotland. There isn't even any red in the Scottish flag.

Guy Cox
Sydney, Australia
Red deer and squirrels are native species to the British Isles, not just Scotland. Red squirrels have tended to be driven out by introduced North American grey squirrels, so I am glad some still survive in Scotland. Red deer are still around in most of the islands of Britain, it's just that Scotland has more suitable habitats. And when it comes to red animals, nothing could be more spectacularly red than the orangutan, and that lives a long way away from Scotland! ▮

Answers

Quick quiz #284 *Answers*

1 The Berlin specimen
2 Archie
3 Olympus Mons
4 Sublimation
5 Three

Cryptic crossword #152 *Answers*

ACROSS 1 Wasp, **3** Space bar, **9** Roadies, **10** Nares, **11** Petrostate, **13** Office, **15** At odds, **17** All-nighter, **20** Error, **21** Iron man, **22** REM sleep, **23** Exec

DOWN 1 Wormwood, **2** Scalp, **4** Piston, **5** Constitution, **6** Berated, **7** Rust, **8** Birth control, **12** Isotonic, **14** Fulcrum, **16** Ignite, **18** Remix, **19** Weir

#54 New year, new numbers *Solution*

1-10 can be made as:
1 = −2 + 0 − 2 + 5,
2 = 2 + (0 × 2 × 5),
3 = −2 + (0 × 2) + 5,
4 = 2 + 2 − (5 × 0),
5 = 2 + 0 − 2 + 5,
6 = (2 ÷ 2) + 5 + 0,
7 = (2 × 0) + 2 + 5,
8 = −2 + 0 + (2 × 5),
9 = 2 + 0 + 2 + 5 and
10 = (2 × 0) + (2 × 5).

Solutions for 11-30 (with the digits in order) can be found using 2^0 and 0! in places to make 1, and joining digits into two-digit numbers to make 20 and 25.

To satisfy the order requirement, the solutions given for 4 and 6 can now be made as 2 − 0! − 2 + 5 and 2 + 0! − 2 + 5, respectively.

An intelligent approach?

Feedback's ears always prick up when we see a publication with a self-aggrandising title. So we latched with interest onto a social media post by Rebecca Sear, a demographer at Brunel University London, who noted that publisher Elsevier has "chosen new editors for *Intelligence*".

Intelligence, you see, is a scientific journal that publishes studies that make "a substantial contribution to an understanding of the nature and function of intelligence". Feedback cannot verify that the editors have been changed, because the journal's "About" page hasn't been updated, but it did advertise for a new editor-in-chief in January 2024. There has been a report that most of the editorial board has resigned in protest at the appointment of the new editor(s), but since that report appeared on a far-right website, Feedback is disinclined to believe it without further evidence.

Hang on, readers may be thinking. How did we get from a scientific journal replacing its editors to a far-right website? The thing is, intelligence research has sometimes been misused to justify claims of racial superiority, especially during the eugenics movement of the early 20th century. And *Intelligence* has published research that your racist uncle might quote approvingly.

Someone at Elsevier appears to have noticed. *The Guardian* has reported the publisher was reviewing papers by the late Richard Lynn, who claimed to have found variations in IQ between countries – including in papers in *Intelligence*.

This is all getting a bit dark, so let's move swiftly forward to the other issue with *Intelligence*: its apparent lack of its supposed defining trait. Sear highlighted a paper with the innocuous-seeming title "Temperature and evolutionary novelty as forces behind the evolution of general intelligence".

Its thrust is that, when some *Homo sapiens* populations first migrated outside Africa, they encountered all sorts of novel conditions, like different climates. This prompted them to evolve a greater level of intelligence. What this means for African populations is left to the reader to infer.

If this all sounds like something from the bad old days of Victorian science, Feedback regrets to inform you that this paper was actually first published online in 2007. However, if you swallow your nausea and look closer, a true delight emerges.

The first issue is that the author calculates the distances populations travelled "as the crow flies". You can't use straight-line distances as even a first approximation for the history of human migration, which involved people journeying to the far north-east of Asia, crossing into North America and onwards to the southern tip of South America.

But it gets better. In the same sentence, the paper's author says he calculated the distance "using the Pythagoras' theorem". Readers will recall that Pythagoras' theorem only applies to flat planes and doesn't work for curved surfaces. Yes, this study about the racial origins of intelligence is built on the assumption that Earth is flat.

With immense academic restraint, a 2009 rebuttal suggested this study might be "questionable". Other psychologists brought the problem to the journal's attention, only to be told that their critiques were "wholly negative and nitpicking". The paper remains live.

Accordingly, Feedback would like to nominate the journal *Intelligence* for the 2025 Reverse Nominative Determinism Award.

Twisteddoodles *for New Scientist*

Got a story for Feedback?
Send it to feedback@newscientist.com
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Consideration of items sent in the post will be delayed

Forty lashes

New Scientist reporter Karmela Padavic-Callaghan highlights a paper about why eyelashes are curly, which they describe as "silly enough to be Feedback material". Rude: this is a deeply serious column about serious things.

The research is mostly about the physics of eyelashes, explaining how they transfer water away from our eyes so we can still see when it is raining. This process depends on "a hydrophobic curved flexible fiber array with surface micro-ratchet and macro-curvature". There is a lot of stuff about adhesion forces and the importance of the curvature of the lashes for water drainage.

And then we get to the discussion section where, as Karmela drily notes, "the authors go into aesthetic advice". You see, "modern beauty standards" encourage women to use mascara "to extend and fix eyelashes", which "compromises the protective functions". But fear not, the solution is at hand: "as a tip, for people with sparse eyelashes, hydrophobic curved false eyelashes could offer a practical solution for enhancing appearance while preserving eye protection." Could a patent possibly be pending?

Feedback wonders whether the authors have any advice for middle-aged writers whose eyebrows grow too long, causing them to look like a macaroni penguin unless regularly trimmed. For a friend.

Worst to-be-read pile ever

Feedback has somehow got onto the mailing list for Spines, a tech company aiming to disrupt the publishing industry through the power of artificial intelligence.

By using AI to do the editing and other jobs previously done by skilled and salaried humans, Spines aims to publish 8000 books in 2025. To which Feedback says, yes please. When one looks at the structural problems in the publishing industry, such as the dire fact-checking standards in non-fiction output, one can only conclude that what we really need is a deluge of even more books of an even lower quality.

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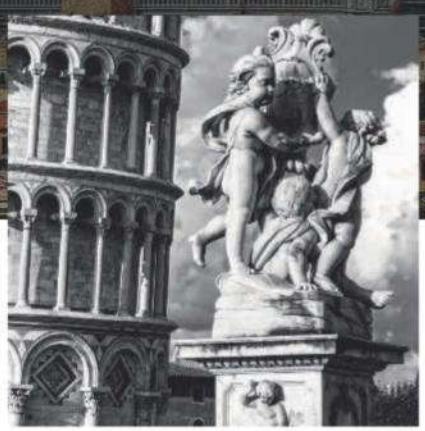

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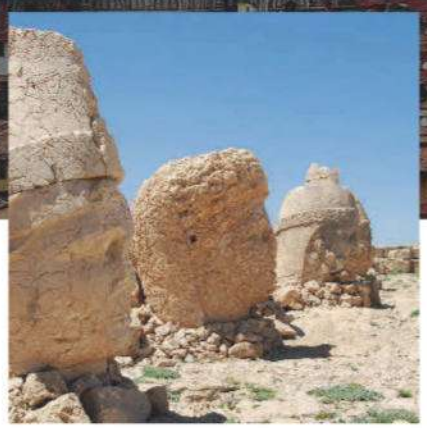

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